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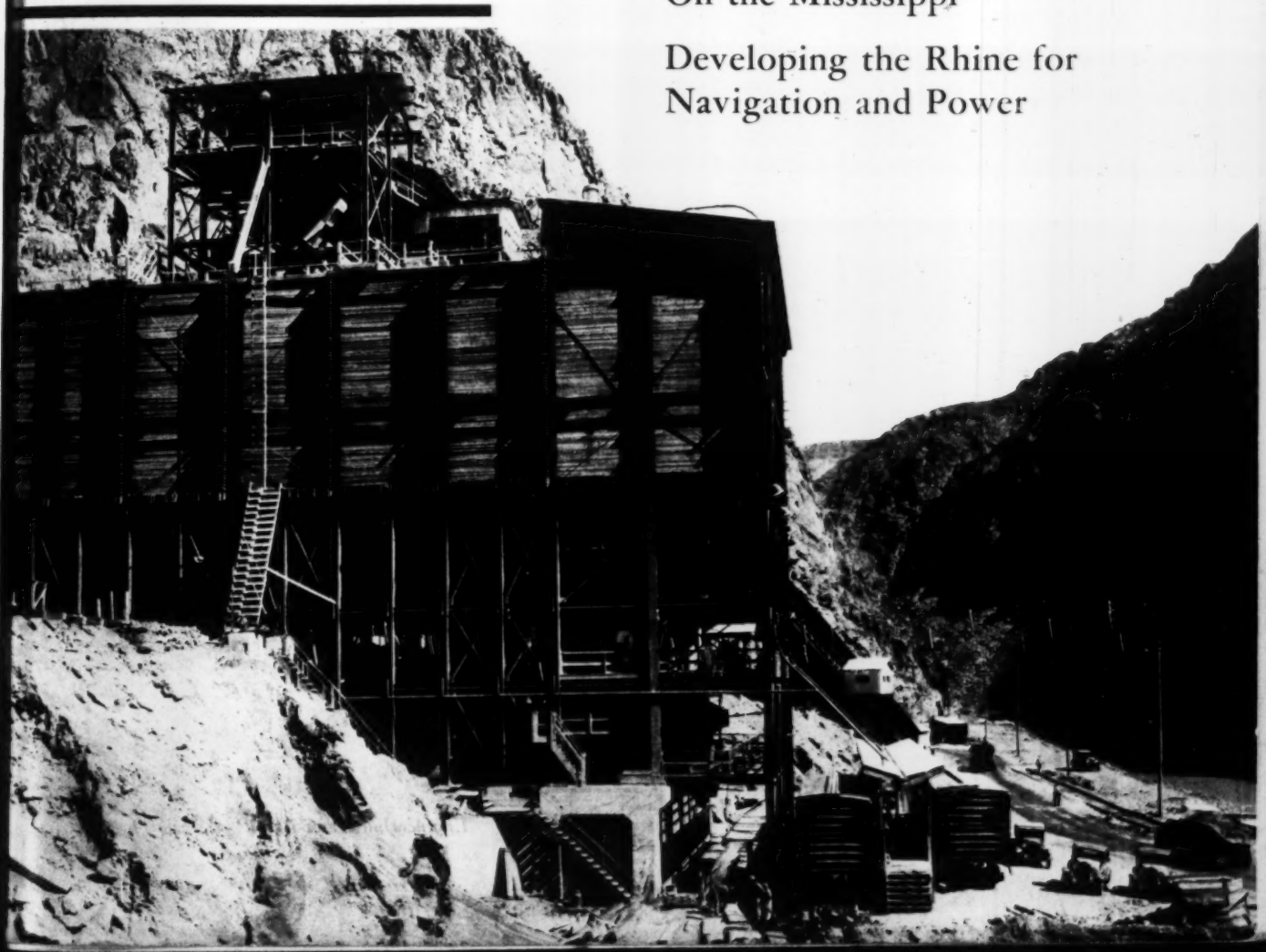
Manufacturing Concrete For Hoover Dam

Thin Concrete Shells For Dome and Vault Roofs

Aluminum Framing in Federal Conservatory

Slab Revetment Equipment On the Mississippi

Developing the Rhine for Navigation and Power



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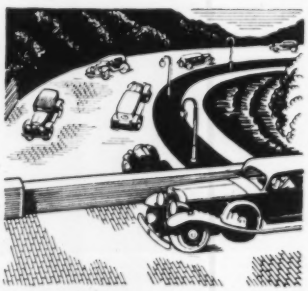
White House Crossing Bridge, Cleveland, Ohio—Opened October, 1929

THE White House Grade-Crossing—most dreaded in Ohio—*was avoided* whenever possible by the knowing motorist. It had cost the lives of 89 people and thousands of dollars worth of property. ◪ After years of study, legislation and negotiation with the railroads involved, this grade-crossing was finally eliminated in 1929. The bridge that now spans it is 1375 feet in length. The approaches are 829 feet on the west and 200 feet on the east. ◪ It is fitting that this fine span, which has been called "the gateway between Cleveland and the industrial cities of Akron, Canton and the Mahoning Valley," should be crowned by a Modern Brick-Surfaced Pavement. ◪ The White House Crossing Bridge is not only a notable engineering feat, but is also a monument to the progress of modern transportation. The brick surface was designed for permanency—as the bridge is permanent; it was designed for smoothness and beauty—even as the bridge is beautiful; and it was designed for the ultimate economy of the taxpayer—required, as was the bridge itself, by the economics of transportation.



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F. E. Schmitt, Editor

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The First Quarter and After

WITH Spring and the second quarter advancing, all eyes turn forward toward midyear. What may we look for? Optimists though we are, we recognize that the first quarter brought disappointment.

The soundness of banks and the financial system has been restored by the credit legislation of two months ago. Yet credit and business are not vigorous; the passing weeks show that their hoped-for rehabilitation through the financial measures is imperceptibly slow. And because of this slowness the expectation that the measures would arrest deflation and revalorize the country's wealth and productive power finds itself disappointed. Financial courage to invest, to expand, to invigorate, is at a low ebb. The burden of raising the business structure to new heights has fallen on industry and the private citizen. What is *their* state?

INDUSTRY is doing less and less, making larger and larger negative profit, and competing more intensely for the shrinking remnants of business. It seeks anxiously for stabilization, has been seeking it for months, but is unable to find the secret of adjusting many factories to a demand barely large enough for one.

The citizen is hardly better off. He is, or fears he is, on the way to losing his job—what is left of it. The usually active Springtime shows a condition of idleness comparable to last winter's sorry record. Our greatest industrial state reports that the heavy manufacturing month of March showed more unemployment than February, a poor month. Family earning power, purchasing power and solvency are slipping.

THESE are the essential facts, and they spell a problem. The unhappy fact is that the country is anemic; its channels of circulation have too little of the vital fluid—money—and therefore its circulation is slowing.

Liquidation is sound when the country is in health, but at present it operates harmfully by drawing money from circulation and locking it up in the vaults. Less money means less business; less business means less employment and buying; less buying means lower prices and larger debts, more debt collection and still less money at work—a vicious circle. We need more money in the hands of commerce, industry and the citizen, and we need to make it move more freely.

If the first quarter, then, made a notable accomplishment in reestablishing the foundation of confidence by supporting the banking system with the unquestioned assurance of national credit, it failed as significantly in putting the renewed confidence and increased supply of money to effective use. Setting money to work is therefore the immediate task.

Many ways have been proposed to increase circulation and revive buying power and trade, but only one meets the test—employment. Employment is the direct and healthy way of restoring activity and solvency. When men are put to work, the sound and thrifty process of living on an earned wage is restored, and the whole nation feels the revival.

Given time, the industries and utilities can provide this employment. Enterprise can help, as many fields of production and merchandising are even now demonstrating. But the developments of the last month are convincing evidence that this process is too slow and too weak to overcome the continued downward trend. Nothing is at hand to give large-scale employment quickly except public works.

AN AGGRESSIVE program of building public works is the day's compelling need. Public works are productive, and turn into permanent wealth every dollar spent upon them. Their creation draws into the cycle of production every industry and every type of worker. The worst happening of the year is that, instead of increasing, public works have been decreased as states and cities were forced to cut their programs or even discontinue work in progress because of insufficient funds. Resumption of discontinued projects and the undertaking of an enlarged program is our sole reliance for revival.

The banking and investing community has heretofore opposed public-works expansion for fear of excessive tax and loan burdens. Very slowly is it overcoming this fear. Congress, realizing the situation, has given consideration to federal loans by which cities and states could carry out their works, but it has not yet shown determination to proceed with the plan. No action has resulted. The administration has been consistently hostile, and business leaders have equally opposed public works, without, however, offering any alternative. As the stalemate continues, each day brings greater conviction that their opposition is purely destructive, and they may be laying the foundation for events far worse than the evils they now seek to escape.

THE stalemate must be broken. Today's situation requires quick and aggressive action. We cannot longer wait on the slow processes of the bond market and the desire of bankers to loan funds. Two months of bitter disappointment show that results cannot be expected from this course, and that the only course left is to provide credit for public works through a federal agency. Upon it depend the fortunes of business and wage-earner alike. It is time for engineers to enlist the full support of business men, bankers and civic leaders in bringing the plan to quick action and organizing the country and their community for its execution.

NOTES OF THE WEEK

Thought Is Progressing

IT IS not many years since the U. S. Steel Corp. ended the last vestige of the twelve-hour working day in its plants, after having said repeatedly that it could not be done. The great change in industrial thinking since those days is signalized by the fact that a few weeks ago the present head of the corporation made the forecast that shorter working hours in industry will be the inevitable outcome of adjustment of production to demand. Most of the change was probably wrought by the last two years' experience, and to this extent it reflects not only a profoundly significant progress in the thinking of industrial leaders but also an advance in understanding that we are all undergoing. Far-reaching effects may be looked for from this advance. So soon as everyone comes to appreciate that overproduction means overwork—men and machines working longer than they need to—many changes in our economic organization and relations will follow. The new understanding, if well applied, will help correct our present economic instability.

Make Economy Sound

GREAT battles for federal expense reduction make the current fortnight historic. Those who favor reduction have so far won all along the line, and the outlook at the moment is for heavy cuts in departmental expenditures. How far the government's construction activities will be involved remains to be seen, but there is little doubt that many technical services will be affected. Regrettable as this is, it is unavoidable on the view that even in these utterly abnormal times the country must live within current income—a new and radical theory, not followed by the government in the war years and not followed by corporations or private citizens at present, for all of them are drawing on capital to live. We heartily disbelieve in the theory. But however unnecessary and heroic the retrenchment may be, if it is the majority demand it must be accepted. The task then is to see that the least possible harm will be done through destructive curtailment of technical services whose value lies in continuity. There are many such in our present governmental activities, among them the stream gagings and hydrologic studies. Engineers can perform useful service in pointing out to their representatives what work should go on unchecked. There are parasite services that can be trimmed down or eliminated to greater advantage.

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One Way to Confidence

SCARSDALE, a New York village, has as its mayor Fred Lavis, well-known engineer. Perhaps this is why it is making a bold stroke to overcome the lack of investor confidence that now stands in the way of municipal security issues. In preparing to sell bonds for improvements the village is sending out a full statement of its condition, in which it sets forth its assets and liabilities, the state of tax collections and other pertinent data to convince purchasers of the soundness of its bonds. This is frank and fair procedure, worth widespread adoption. If every intending bond buyer had similar facts laid before him he would less often risk his money in a gamble and would have less occasion to feel anxious about his investment; prices would therefore be higher and more stable. Lack of frankness as well as lack of investment and supervision helped to bring South American improvement bonds to their present unfavorable rating, for advance disclosure of all facts would have directed early attention to the steps necessary to make and keep them sound. Lack of frankness has characterized also many corporation statements. There is every reason for cities to follow a better course. Scarsdale shows the way; followed universally by governments and corporations it would work toward rapid rebuilding of public confidence.

Ingenious Revetment Equipment

NOTABLE ingenuity has been displayed by engineers on the Mississippi River in adapting ordinary equipment to meet their special needs or in modifying such equipment to increase its usefulness in meeting their problems. Such ingenuity has been displayed both in levee construction and in the building and placing of revetments. An example of the latter is given in this issue in an article by Major Brehon Somervell, describing concrete-slab revetment construction as practiced in the Memphis district. In important details the equipment used there varies from that used elsewhere on the river, previously described, for placing brush mattresses and mats of small articulated slabs of concrete. In the Memphis district an articulated mat of large thin precast slabs of concrete, originally laid shingle-fashion but now laid without lapping, is used for that part of the revetment laid under water, while the remainder is thin slab cast in place. All equipment is floating. It includes modified tower and dragline excavators for grading the banks and concrete mixers for placing concrete in the sloping revetment slab which are adaptions of the scheme used in road-paving mixers. All, in a way, are special pieces of equipment, and yet economy and flexibility of use have been obtained in most of them by the use of standard units. They are excellent illustrations of efficient equipment development.

What Is Perfection?

IN A REPORT on the multiple basing-point system of establishing commodity prices, just completed, the Federal Trade Commission denounces the system as one which produces "imperfect competition." It does not explain wherein the imperfection exists—that is, whether the system gives too much to the consumer or too much to the producer. If one considers the large continuing losses of the cement industry last year and this, one must conclude that the system did not succeed in giving the producer too much; yet the commission's words reflect an unmistakable belief that the consumer is being exploited. Even though lacking in clearness the report would be constructive if it set forth how a price system giving perfect competition may be devised. It fails to do this, however. Its most useful result is the showing that

a transportation expense of more than forty million dollars was absorbed by the industry in a single year, and that much of this expense resulted from cross-hauling (one mill selling in another's economic range and vice versa). On this point it makes the somewhat obscure comment that "the habitual practice of cross-hauling appears to be due primarily to a rather rigid maintenance of mill prices at a relatively high level and only secondarily to tonnage hunger as often alleged." The remark indicates that the commission believes the price system and distribution practices of the cement industry to be uneconomic, bringing losses to both producer and consumer. If so, affirmative recommendation of a better price system is particularly desirable. Lacking this, the charge of imperfect competition does no more than raise the puzzling question as to what kind of competition is perfect.

Juggling Loads

LONG have the engineer and contractor juggled heavy foundation loads from one set of supports to another and back again by a variety of ingenious methods. Although the art of underpinning is old, its technique is constantly changing to keep pace with modern construction development. Recent examples of difficult underpinning include the placing of new foundations under the old Manhattan Life building and the support of block after block of heavy buildings along the Nassau St. subway line, both in New York. We are able to present this week three articles portraying separate underpinning projects, each for a different purpose and handled by different methods. In one project heavy foundations of the New York post office were shifted to allow for railroad platform alterations underneath. In another project new foundations were installed to stop the settlement of a power house. In the third project five miles of piling was jacked down under a subway structure to permit the building of a new line below. Each is an excellent example of the skill and finesse that has been developed in the delicate operation of transferring foundation loads. Apparently nothing daunts the underpinning engineer today. Given a lever and a fulcrum, Archimedes would have moved the world; given half a chance, the engineer will transfer it to a new set of supports.

What Science Hath Wrought

SCIENCE applied to the field of concrete making has changed concrete mixing from a haphazard uncertainty to precise and carefully controlled procedure. Good concrete is now recognized as the product of correct proportioning and proper mixing in addition to suitable materials. Rigid specifications alone will not produce good concrete in quantity; equipment that can be properly controlled is essential in addition to the specified requirements. Much to their credit, manufacturers have met the demand for such equipment. Evidence of their achievements was shown in the Koon Dam concrete plant installation, described in these pages Dec. 31 last, and is again brought to notice in the description of the batching equipment at Hoover Dam appearing in this issue. Consistency indicators, automatic control, rapid moisture determination in aggregates, electrical cutoffs and graphical recording devices were unknown in concrete plant installations but a short time ago; present indications are that they will soon be found on every large concrete job. Commercial concrete plants are already turning to these scientific instruments for the production of a more consistent and high-grade product. The next step will be to provide the smaller concrete plants with the same precise control as has been developed for larger installations, thereby giving every concrete job the benefit of scientific proportioning and mixing. Better concrete will be the result of such advance.

Engineering Advice Needed

A SERVICE to the country generally has been done by the American Institute of Consulting Engineers in a statement addressed to the Senate finance committee giving pertinent facts concerning the investment of capital in Latin America. The Senate finance committee has been investigating conditions surrounding the investment of funds from this country in foreign fields to determine why many investments so made have turned out to be a failure. It sought to learn where responsibility for this development lay. The Institute's report —prepared by engineers of long experience in Latin America—places responsibility squarely on the bankers for failure to get disinterested opinion on the soundness of the ventures they were financing and to set up proper checks upon the way money was spent.

Money has been loaned to Latin American governments in the belief that it was to be used to construct useful public works without knowledge as to the need for or revenue-producing value of the proposed works, without stipulation that the money was to be spent only upon approved work, and without providing for proper control of its expenditures. As far back as 1919 the Institute began urging upon American bankers the desirability of universal adoption of a practice followed by most British bankers but by only a very few in America —namely, employing independent consultants to pass upon the feasibility of projects for which they have been asked to provide funds. If after investigation the project appears attractive, British bankers do not pass out the money without stipulating that they retain control over the manner in which it is spent, and usually even over the operation of the project when completed. A second time in 1923, again in 1929, and once again in 1928, the Institute urged the adoption of this practice upon the principal investment houses of this country. Their warnings went without effect.

The bankers, it appears, saw only the Institute's selfish interest in urging engineering investigation and control and so ignored it, being content to take any bond issue that came along regardless of its merit so long as they could make a profit out of the underwriting, passing the bonds on to the trusting public which, in the end, "holds the bag." The folly of that practice is now all too obvious. Much of the money so invested has been squandered on ill-conceived undertakings, investors in this country have lost or stand to lose most or all of their principal, and confidence in the banking houses that sold them the bonds has been lost. Distrust of all Latin American investments has been developed. But worst of all, international distrust and ill-will have been built up just at a time when trust and good-will are most needed.

A frank and convincing statement of what could have been done to protect American investments abroad, even though it comes from an interested party, cannot but help to insure the adoption of sound practices in the future. The Institute is to be congratulated for having risked arousing antagonism among bankers in order to put the facts clearly before the public.

Automatic Material Batchers at Hoover Dam

Electrically controlled equipment installed to batch and mix 280 cu.yd. an hour to meet rigid specification requirements—Composition and consistency of each batch recorded graphically

THE CONTRACTORS' construction program for the Hoover Dam calls first for a mixing plant located in the canyon near river level and then the shifting of this plant wholly or in part higher up the canyon side. The low-level plant has been installed with four 4-yd. mixers and provision for two more. Fig. 1 shows the plant as installed. Its four mixers have a combined average capacity of 280 cu.yd. an hour. This requires the handling of a carload of aggregate every 8 min. The following article describes the arrangement and general equipment and operating procedure of the batching plant. —EDITOR.

AUTOMATIC AGGREGATE batching equipment containing new features has been installed at Hoover Dam by Six Companies, Inc., as part of the elaborate concrete mixing plant built for the manufacture of nearly 4,500,000 cu.yd. of concrete required for the dam, tunnel lining, spillways and control and diversion works. Because of the size and character of the structures, unusually rigid requirements were specified for proportioning and mixing the concrete.

The contractor is required to provide such facilities and equipment as are necessary to determine and control accurately the relative amounts of the various materials (including water, cement and each individual size of aggregate) entering the concrete. The amount of cement and each individual size of aggregate entering each batch is required to be determined by direct-weighing equipment complying with the following requirements:

Brief of specifications

1. The accuracy of the weighing equipment shall conform to the requirements of the U. S. Bureau of Standards.

2. The equipment shall include a visible dial or equally suitable device, which will accurately register the scale load at any stage of the weighing operation from zero to full capacity.

3. The equipment shall include an accurate automatic recorder (capable of being locked) for recording visibly and graphically the time of weighing and the actual amount of each separate concrete ingredient weighed out.

4. The equipment shall be capable of ready adjustment for compensating for the varying weight of moisture contained in the aggregate or for changing the proportionate batch weight.

5. The equipment shall be capable of controlling the delivery of material for weighing to within 1 per cent of the specified weight of cement and 2 per cent of the specified weight of each separate aggregate.

6. The equipment shall be so arranged as to permit the convenient removal of overweight material in excess of the prescribed limits.

The amount of water used is to be changed as required to secure concrete of proper consistency and to adjust for any variation in the moisture content in the aggregates as they enter the mixer, provided that the inundation method of controlling the water content will not be required. The quantity of water entering the mixer is to be measured by a device capable of measuring it in varying amounts within a tolerance of 1 per cent. The equipment is to include an accurate automatic recorder, capable of being locked, for recording visibly and graphically the time of measurement and the actual quantity of water used in each batch. The quantity of water entering any batch is to be just sufficient, with a normal mixing period, to produce concrete of the required consistency, as determined by the government inspector. Excessive overmixing requiring additions of water to preserve the required consistency are not permitted. Uniformity in concrete consist-

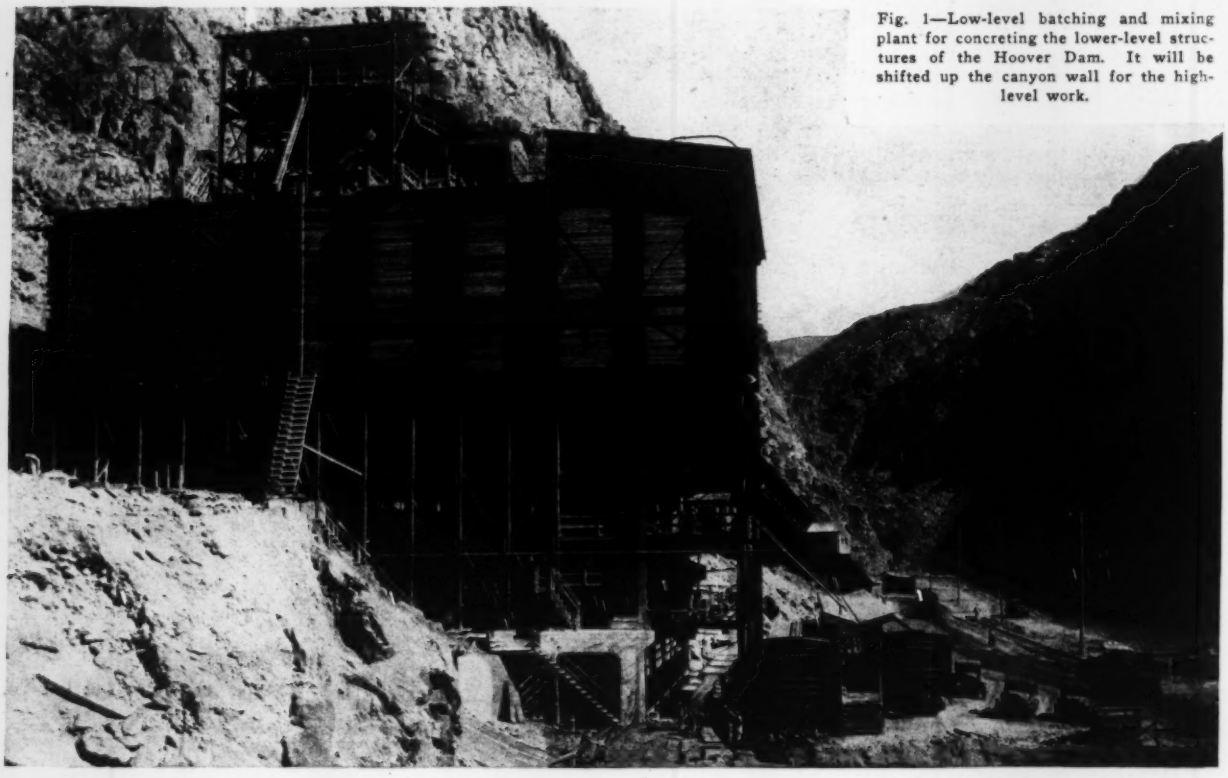


Fig. 1—Low-level batching and mixing plant for concreting the lower-level structures of the Hoover Dam. It will be shifted up the canyon wall for the high-level work.

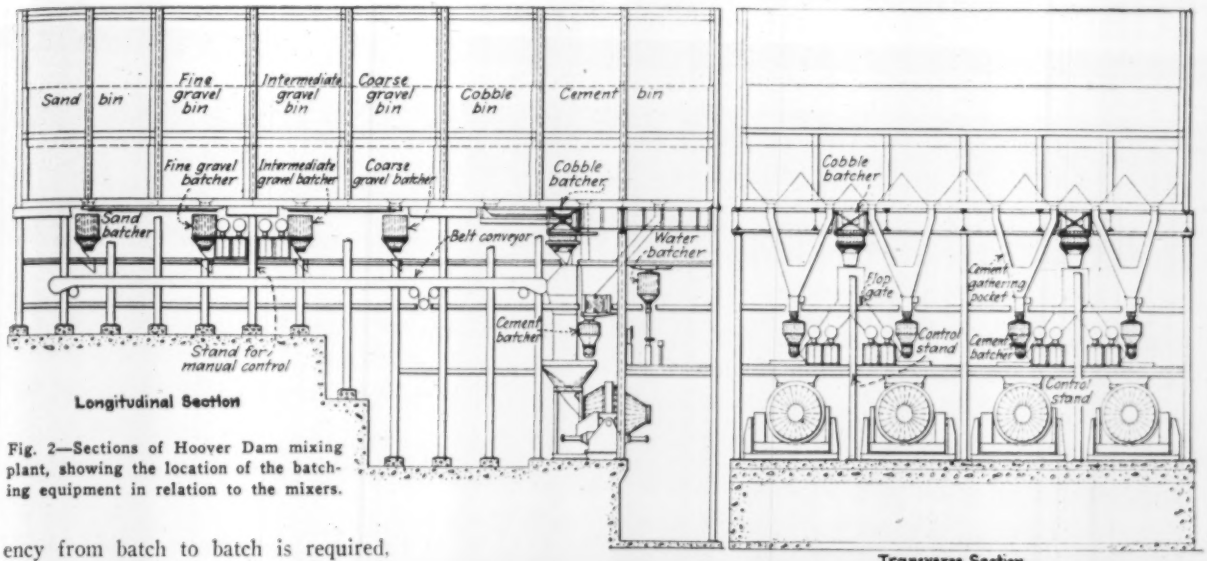


Fig. 2—Sections of Hoover Dam mixing plant, showing the location of the batching equipment in relation to the mixers.

ency from batch to batch is required, and the contractor shall equip each mixer with an efficient recording consistency gage and timer or shall provide equally suitable equipment or means for indicating and recording consistency. All graphic charts, after recordation, become the property of the government.

General layout

The batching equipment was required to handle five different sizes of aggregates (sand, fine gravel, intermediate gravel, coarse gravel and cobbles) and also cement and water. Although single-material weigh batchers were not specifically called for by the Reclamation Bureau's engineers, they were regarded by them with favor and considered most desirable by the contractors.

In laying out the mixing plant the contractor had called for a live storage of approximately 5,000 cu.yd., one-fourth of which was for cement. The accompanying drawing shows the bin arrangement parallel to the front of the plant and to the line of mixers at the front. This arrangement located the bins progressively farther away from the mixers and required conveyors to take material from the farther bins to the mixers. Two belt conveyors were installed underneath the bins, both running from the rear to the front, one on the axial line between the two right-hand mixers and the other on the axial line between the two left-hand mixers. A batching hopper from each bin bottom was installed over each conveyor line, and at the discharge end of each conveyor a two-way chute enabled the material to be shunted right or left into the charging hopper of either mixer. There is a cement batcher for each mixer and a water batcher for each pair of mixers. This arrangement is shown diagrammatically by Fig. 2.

Equipment and operating details

While the plant is designed for complete automatic operation, the contractors insisted, as a primary provision, that it be arranged to cut over to manual operation at any time. The stand for manual operation is shown by Figs. 2 and 3.

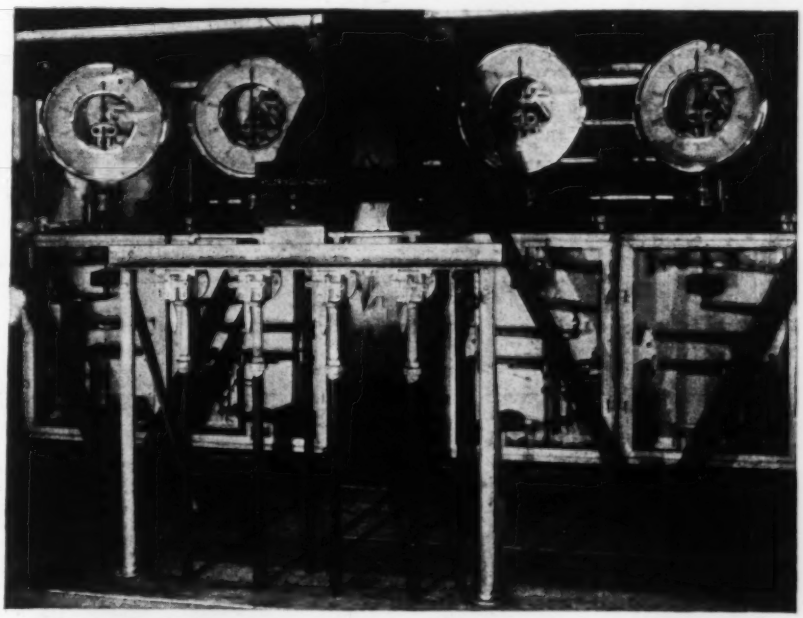


Fig. 3—Stand for manual control of sand and fine, intermediate and coarse aggregate batching. Cement and water are manually controlled in all batching.

The automatic batchers use the old principle of automatic weighing, wherein the feeding is first by a major stream and then by a dribble stream to the weigh batchers. The major stream is introduced very rapidly to conserve batching time; the final or dribble stream is introduced slowly to obtain maximum accuracy in the final weight.

The filling of the sand and gravel batchers (Fig. 4) is controlled by air valves, the cobble batchers by means of motor-driven apron feeders, the cement batchers (Fig. 5) by special motor-driven screw feeders, and the water batchers by hand- or magnet-operated valves. The discharge gates on the aggregate batchers are unlocked by means of solenoids and are counter-balanced to close automatically when empty. They are interlocked to prevent filling unless first the door and then the latch are closed. The discharge is regulated through a sequence timer to give ribbon, or proportional, feeding of materials to the conveyor belt and thence to the mixers.

The cement-discharge gates are actuated by air cylinders manually controlled. The water-discharge valves are also manually controlled by the mixer operator. This gives manual timing of the cement and water charging so that they may be coordinated properly with the aggregate charging. The operator may chute an initial charge of water, follow this by starting the aggregate charging and then proportionally introduce the water

and cement. The mixer-charging hoppers have dry cement compartments to promote ribbon feeding of the cement with the aggregates.

When set for automatic operation, the filling operations start automatically when the discharge gates close and are interlocked through the gate mechanism. The major stream is introduced until the weight reaches a predetermined point, then a secondary control introduces the final or dribble flow until the exact weight is reached. This operation repeats automatically as soon as the batchers are discharged (provision being incorporated to interrupt it when desired). If desired, all weight-control parts may be sealed and locked, leaving to the manual control only the operation of the discharge push-buttons for the aggregates, the air valve controlling the cement discharge and the hand lever controlling the water discharge (Fig. 5).

Signal lights are provided to show which batchers are in service and when they are filled and ready for discharge. The operator watches the rate of discharge of cement and water into the mixer and may regulate the water flow to give the exact desirable mixing action during the charging of the mixer. Tests on paving mixers and on the Hoover Dam mixers at the factory showed that best results are obtained by first introducing a limited amount of water in the empty mixer drum to scour the shell and blades and then by feeding the remainder of the water proportionally to the introduction of the aggregates and cement. This method prevents material from sticking to the shell and blades and also diffuses the water promptly throughout the aggregates as fast as they enter the mixer. This control of the water charging, coupled with the ribbon feeding of the aggregates and cement, increases the efficiency of the mixer by avoiding the waste of time generally consumed in breaking up segregated masses of sand, cement and water in the mixer before the true mixing action may start. Less cleaning of the mixer is required, and less splashing occurs.

A consistency indicator for each mixer is placed immediately before the operator, and each batch of mixed concrete is checked for consistency before dis-

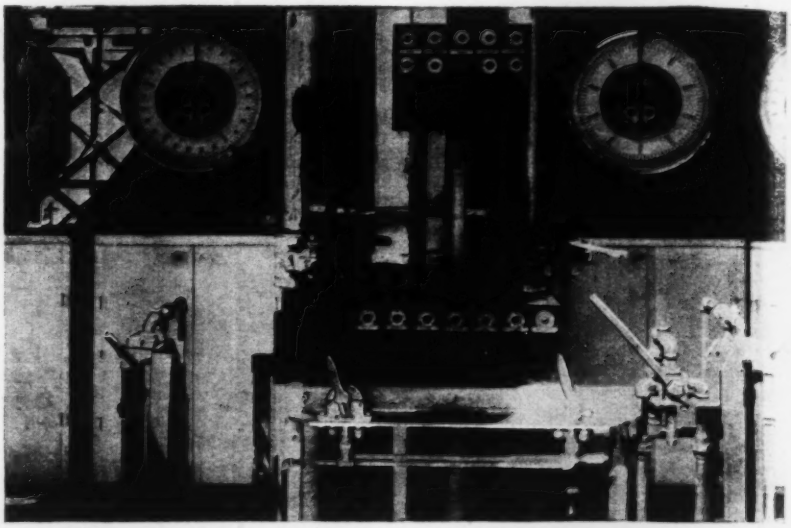


Fig. 5—Stand for automatic operation of aggregate batchers and manual operation of water and cement batchers for each pair of mixers.

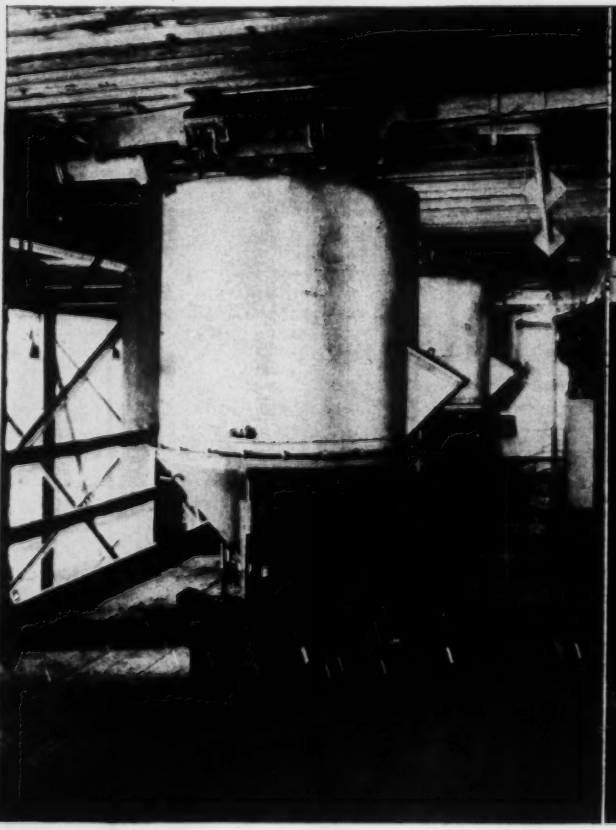


Fig. 4*a*—Battery of aggregate batchers with air-operated roller gates, magnet discharge and overload-removal pockets.

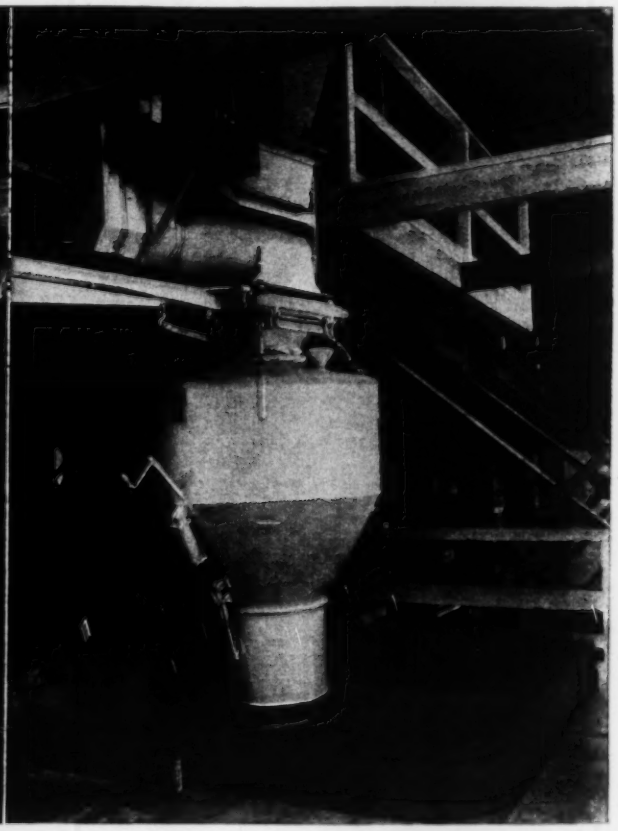


Fig. 4*b*—Cement batcher with air-operated discharge gates, twin-screw feeders and automatic motor drive.

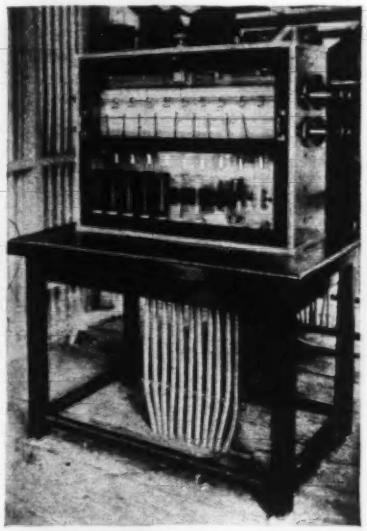


Fig. 6—Device recording automatically the weight of each ingredient in each batch of concrete and also the consistency of each batch.

charge. By this consistency indicator and the manual control of the water feed to the mixer, successive batches are brought to uniform consistency or to that required for the placing operations.

These controls, coupled with the complete and elaborate devices and methods in screening, washing and storing the aggregates, enable the operators to make concrete to any desired specification promptly and with certainty of results. All juggling of water introduced, guessing as to workability and erratic batches are eliminated.

A complete and continuous record of the separate ingredient weights in every batch of concrete and also the consistency of each batch is made automatically on a single roll of paper in a graphic recorder (Fig. 6) for each batching plant. The record enables the inspectors to make sure that the specifications for quantities of each aggregate, cement and water, and also consistency are adhered to in every batch of concrete. With these records available, test cores can be taken from any section of the dam at any future time, and the components of the mixed concrete can be re-established by referring to the graph and job records.

The design and specifications for the Hoover Dam were prepared in the Denver office of the U. S. Bureau of Reclamation, under the direction of Raymond F. Walter, chief engineer, and John L. Savage, designing engineer. Walter R. Young is the construction engineer for the bureau on the project. The concrete plant was designed and installed by Six Companies, Inc., which has the contract for building Hoover Dam, the power plant and appurtenant works. The batching equipment was designed and furnished by the C. S. Johnson Co., Champaign, Ill.

Thin Concrete Shells for Domes and Barrel-Vault Roofs

Design known as Zeiss-Dywidag system in Europe to be introduced in this country—Basic feature is substitution of beam action for arch action

THIN concrete shell design for domes and barrel-vault roofs, in which beam action is substituted for arch action, is a comparatively new type of construction that has been applied rather extensively in Europe and is to be introduced in this country. The principle of the design, as pointed out in *Engineering News-Record* of Feb. 21, 1929, p. 321, is that in an arch or vault barrel of uniform thickness and closed by end webs or diaphragms the action is that of a free supported beam of large moment of inertia rather than that of an arch. Domes of this type for the market hall at Leipzig, Germany, are shown in Fig. 1. Here the dead weight but becomes the fundamental part of a self-supporting construction free from the undesirable properties of an arch. In the design for a roof of 490-ft. span two concentric shells with a combined thickness of 6½ in. were to be stiffened by connecting ribs between them. Yet for this long span the maximum calculated stress in the concrete was only 285 lb.

In general, a shell is a thin curved plate of any shape. It is easily bent, but when stiffened by ribs or frames it becomes capable of supporting loads. For example, silk stretched over the ribs of an umbrella can carry considerable load. In a similar way a thin

Fig. 1—Ribs on domes of Leipzig market eliminate transverse bending in the thin curved slab.

domes, octagonal in plan and 246 ft. in diameter, are formed by four elliptical cylindrical shells 3⅛ in. thick. In such dome construction the curved slab is freed from the usual transverse bending by means of the stiffening effect of radial ribs on the outside of the dome. The barrel-vault roof of an airplane shed at Turin, Italy (Fig. 2), covers an area 540x82 ft. without interior columns. Each vault is 82x38 ft. and 2⅜ in. thick.

In this shell design the aim has been to overcome the disadvantage of concrete for long spans due to the rapid increase of dead weight with the length of span. While the concrete arch has come into extensive use for bridges, where the thrust is taken principally by concrete in compression, it has not been so successful for roofs of long span, owing to the high expense of centering or falsework and the necessity of taking up the end thrust by massive abutments or unsightly tierods. In the shell design the thin slab is not simply

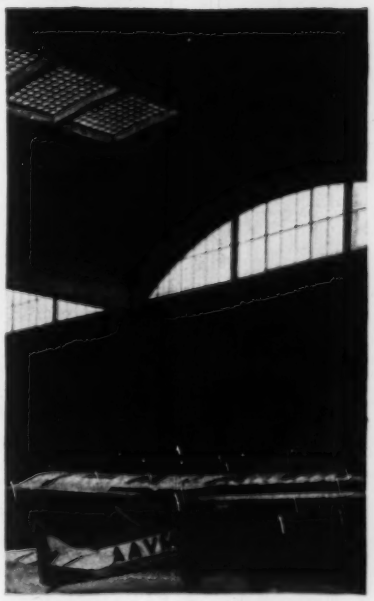


Fig. 2—Barrel vaults of 38-ft. span, 2⅜ in. thick, form roof of airplane shed at Turin, Italy.

curved concrete plate is given load-carrying capacity by providing it with stiffening ribs. For a shell roof the main feature is the elimination of transverse bending in the slab, thus making it possible to keep the thickness within small limits. Calculation of the stresses has been developed to a high degree, while the distribution of internal stress has been checked by experiments with large models and by observations on existing structures.

Shell dome construction

This system was first used for spherical domes, but polygonal domes have been built in which the shell slab spanning between the ridge beams acts like a membrane subject to compression, tension and tangential shear, but is freed of transverse bending by the stiffening effect of arched beams at the intersections of the cylindrical shell (see Fig. 1). At the same time the dome action of the whole system causes horizontal ring stresses, forcing the thrust line to follow the center line of the ridge beams, thereby releasing them, in turn, from bending stresses when symmetrically loaded.

Another outstanding characteristic of the polygonal shell dome is the action of its slab, like that of a system of beams of large section modulus carrying the vertical loads to widely spaced columns. The important feature of shell construction is the saving in weight, with consequent saving in the substructure. The accompanying table compares a shell dome with ordinary masonry or arched rib domes.

COMPARISON OF DOMES

Building	Type	Span, Ft.	Weight, Tons
St. Peter's Church (Rome, 1506–1626)	Stone	131	11,000
Century Hall (Breslau, 1911–1912)	R. con. arched rib	213	7,000
Market Hall (Leipzig, 1928–1929)	R. con. shell	264	2,380

Barrel-vault shell

To take advantage of the membrane action of a dome in covering rectangular areas the barrel-vault shell design was developed, in which the internal stresses are distributed in three directions of space instead of in two directions only, as is the case with ordinary barrel arch construction. The principles of the construction are shown in Fig. 3. Typical features of barrel shell roofs are: (1) the cylindrical shell, whose cross-section is elevated above the thrust line; (2) the stiffening of the shell by rigid end frames or diaphragms, which keep the shell free from bending moments and force the transmission of all loads and thrust by tangential shear to these end frames. In this way the horizontal thrust is decreased from a maximum at the crown to zero at the springing line when the end tangent is vertical. In Fig. 2 these end diaphragms are pierced by large windows and the vaulted shell has skylights.

As in the case of polygonal domes, the action of the shell vaults is similar to that of a system of T-beams in both the longitudinal and the transverse direction. The total rise is the effective depth of the beams resisting bending in a longitudinal direction while the entire length of the vault acts as the flange of the T-beam carrying the moment transversely. Its entire length is effective, since the compressive stress is uniformly distributed throughout, even though the ratio of slab thickness to span may be as little as 1 to 600.

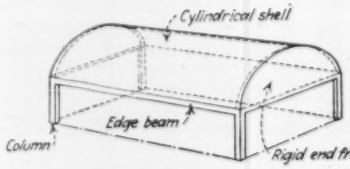
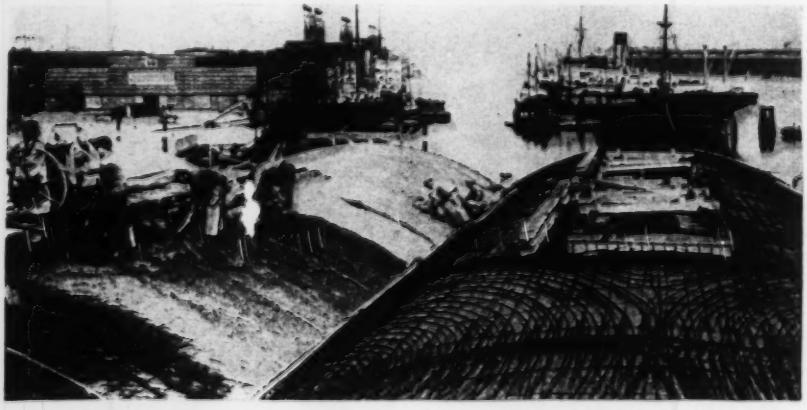


Fig. 3—Barrel-vault with closed ends eliminates arch action.

Steel triangular network is used as centering and can be mounted to form any desired shape of dome or barrel. At first this network was concreted into the shell as a part of the reinforcement, but now it is used only as the centering, with the forms of steel plates or wood or fiber boards placed upon it. Concrete may be applied in the usual manner or by a cement gun.

Fig. 4—Building barrel-vault shell roof at Hamburg. Three layers of steel rod reinforcing are placed to follow principal lines of stress.



Reinforcement consists usually of three layers of plain round ⅜-in. bars following the lines of principal stress very closely. This arrangement is shown in Fig. 4, representing part of a hangar at Hamburg, 1,090x164 ft. with 36 parallel shell vaults 2⅜ in. thick. The vaults are built in units of five each, separated by expansion joints. One-sided cylindrical shells may be constructed to curve down from a ridge beam and form a shed or cantilever roof for stadiums or industrial plants.

This type of construction, invented by Dr. Bauersfeld and Dr. Dischinger and known as the Zeiss-Dywidag system, was first applied in domed roofs for planetariums. It was developed later for roofs over rectangular and polygonal areas, largely by Dr. Dischinger and Dr. Finsterwalder, of Dyckerhoff & Widmann, Wiesbaden, Gemany, which firm owns the patents and has sent A. Tedesko to America as its representative. The American rights have been acquired recently by the Roberts & Schaefer Co., Chicago, and designs will be prepared under the direction of J. E. Kalinka, structural engineer for the company.

Bridge Replaces Car-Ferry in Africa

A second large bridge in Africa is being built to replace a car-ferry service hampered by shoaling of the water and shifting bars. The Zambesi River bridge, 9,000 ft. long, for the Nyassaland Railway, on the east side, was noted in *Engineering News-Record* of Feb. 12, 1931, p. 294, and Sept. 4, 1930, p. 375. The Benue River bridge for the Nigerian Railway, on the west side, which is expected to be completed this year, will be 2,854 ft. long between abutments. It is located at Makurdi, 290 miles from the coast terminal at Port Harcourt, where the river narrows to a rock channel 1 mile in width. Shifting sandbanks have caused increasing trouble, so that the construction of the bridge was decided upon in 1927. There will be three through-truss spans of 240 ft., giving 40 and 65 ft. of headroom at high and low water, respectively. On each side will be five deck spans of 180 ft. Steel caissons sunk by the pneumatic process are founded on rock, except for the two middle piers. All the piers are of concrete, faced with precast blocks.

A solid deck formed by transverse steel troughs filled with concrete is 18 ft. wide between curbs. It carries a track of 3½-ft. gage, but it is so paved as to permit a double lane of highway traffic when trains are not crossing. The bridge was designed by Rendell & Palmer, London, as consulting engineers for the government's colonial department; the contract was let to Sir William Arrol & Co., Glasgow, at $4,800,000 (gold).

Federal Conservatory Uses Aluminum-Alloy Framing

Aluminum trusses, purlins and glazing bars reduce maintenance in moist atmosphere—Columns and smaller trusses are of steel

ALUMINUM used on a large scale for roof trusses and cantilevers distinguishes the framing of the new conservatory of the U. S. Botanic Garden in Washington. Extensive use is also made of aluminum for purlins, girts and glazing bars. Another special feature is the complicated arrangement of trusses in the connection of a triangular roof with the lofty arched or dome roof of the central portion of the structure. Steel columns carrying the aluminum roof cantilevers require heavy anchorages to resist the uplift stresses. The whole building is notable in its general design as well as for the bold use of aluminum as a structural material.

—EDITOR.

CANTILEVER aluminum roof trusses forming the dome and a combination of aluminum and steel for the structural framing are special features of the new conservatory being built for the U. S. Botanic Garden at Washington, D. C. The building is a hollow rectangle about 284x183 ft. in plan, with a transverse portion that divides the inclosed area into two courts about 56x84 ft. This transverse structure, the palm house, is the prominent feature, reaching a height of 88 ft. Along the main front is the subtropical hall, with a width of 46 ft. and height of 50 ft. The two sides and the rear portion, 30 ft. wide and 20 ft. high, will be divided into various sections, such as the orangery, fern houses and tropical fruit house.

This conservatory is the most conspicuous feature of the botanic garden as now relocated on a site that fronts on the south side of Maryland Ave., opposite the grounds of the Capitol. A botanic garden under government authority has existed at Washington for nearly 100 years, having been developed largely after the exploring expedition to the South Seas by Captain Charles Wilkes, U. S. Navy, in 1838-1840, who made a large collection of plants and seeds. Preparation of plans for relocating the garden adjacent to the Mall was authorized by Congress in 1925. The new conservatory will have about 300 ft. of frontage on the south side of Maryland Ave. between First and Second Sts. Behind it will be the open-air botanic garden, triangular in shape, about 393x464 ft., and containing the residence of the director. With this arrangement the entire west side of the Capitol will front upon the botanic garden, the Mall and Pennsylvania Ave., to the exclusion of any private enterprise or development.

Fig. 1—Maryland Ave. front of conservatory for U. S. Botanic Garden at Washington. This architect's drawing shows glazed roofs rising above masonry loggia.

Design of conservatory

Structurally, the design follows the conventional form of conservatory structures, with arched and domed-roof framing carrying a great expanse of glass sheathing. In its details the design presents many features of note. Of special interest and importance is the extensive use of aluminum for structural members, this being the first large structure in which aluminum has been applied for such a purpose. The extent of trusswork involved is indicated in the accompanying illustrations. About 276 tons of steel and 33 tons of aluminum framing have been used.

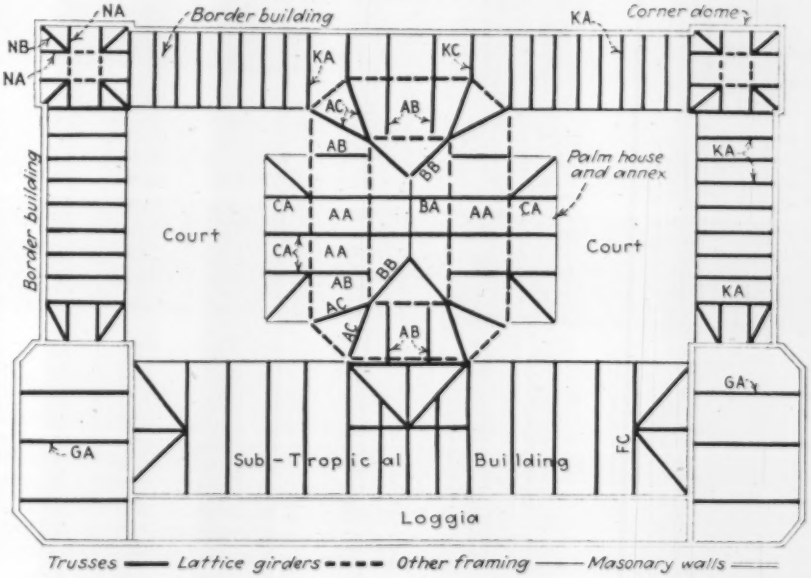
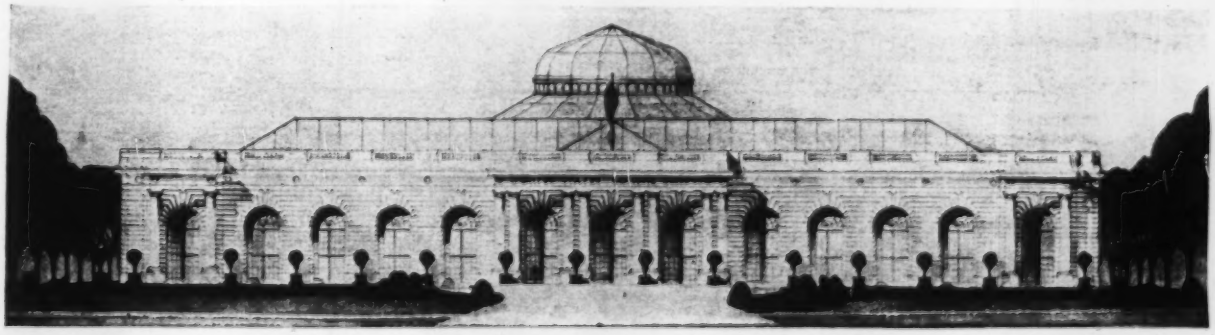


Fig. 2—Framing plan of conservatory indicates complicated arrangement of trusses in combination for dome and arched roofs of various parts of the structure. Numerous forms of roof trussse are required in subtropical room and its connection to palm room.

Architecturally, the main feature is the one-story loggia or entrance hall forming the Maryland Ave. front (Fig. 1), which is of limestone and is carried to a height of about 40 ft. This part of the structure has a flat concrete roof on wall-supported I-beams. Corner structures on this front, utilized for lectures and other gatherings, also have flat concrete roofs, but these are supported by trusses and I-beam framing



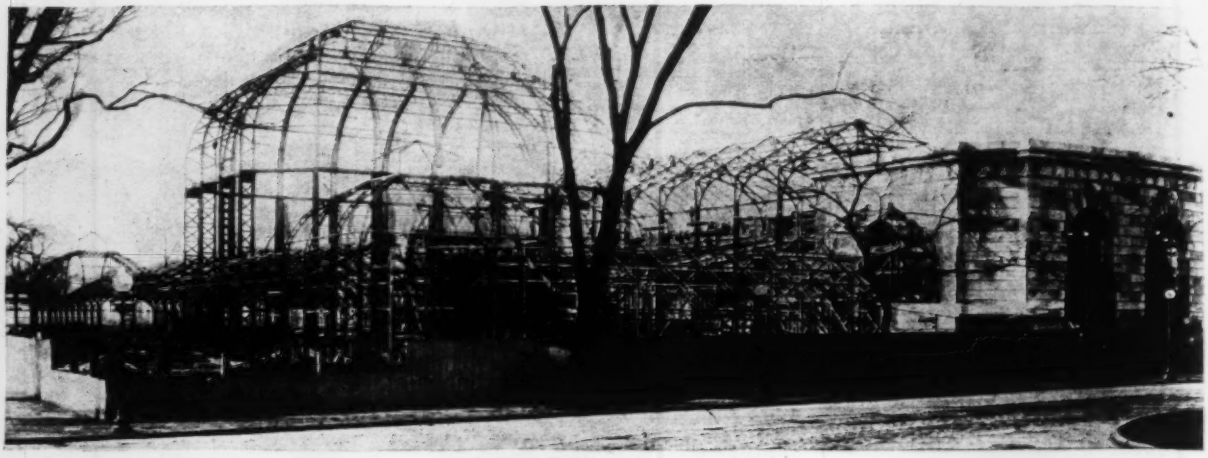


Fig. 3—Steel and aluminum framing for conservatory complete. View taken from rear shows framing for corner domes, border houses and, in the center, the high aluminum dome of the palm house.

(Fig. 2). On the sides and rear the masonry walls are only about 12 ft. in height. Above these walls rise the curved glazed surfaces of the conservatory roof.

Cast-in-place concrete piles about 30 ft. long form the foundations for the walls and colmn footings. These piles, partly in a gravel stratum and partly in clay and filled ground, do not extend to rock or other solid formation.

Palm House—The central and loftiest part of the conservatory is the palm house, about 85x92 ft., and with a clear interior height of about 85 ft. at the center line. As its floor is depressed, the height above street level will be about 81 ft. In the main bay, 66 ft. wide, steel columns 56 ft. high are surmounted by arched aluminum cantilever trusses *AA* and *AB* (Figs. 2 and 4) having a cantilever projection of 20 ft., the opposite cantilevers supporting triangular trusses *BA* of 27½-ft. span.

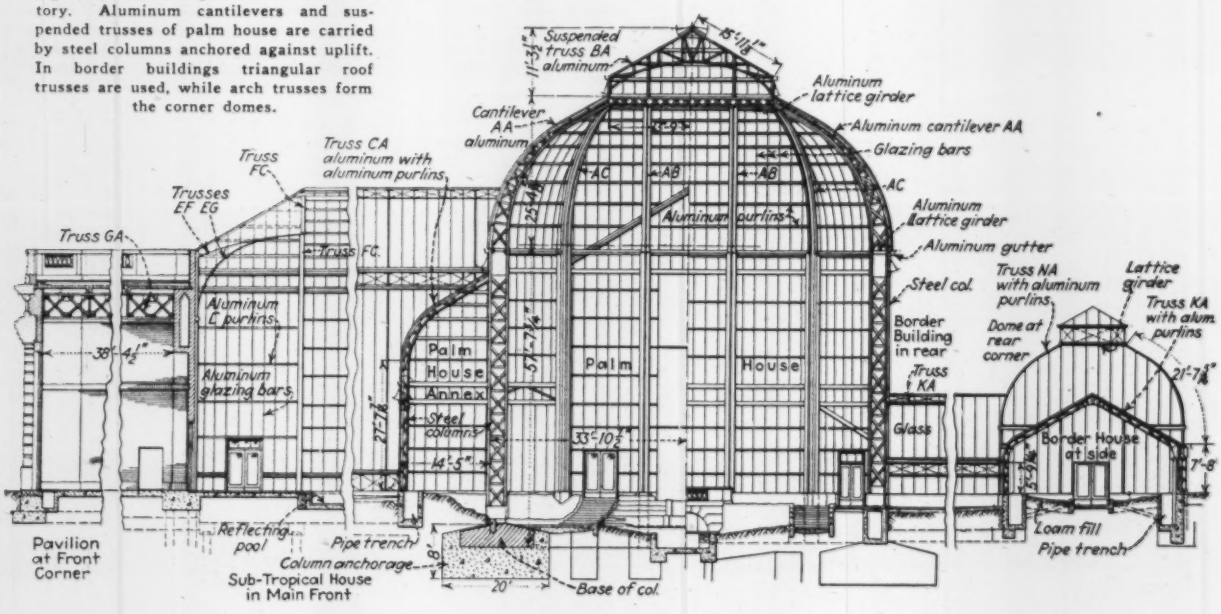
For anchorage against uplift the columns have plate-girder bases 12 ft. long embedded in concrete and anchored to reinforced footings 20 ft. long and 5½ ft. deep. The total weight of each anchorage is estimated at 66 tons. Diagonal trusses *AC* fill in the corners, and two continuous lines of horizontal lattice girders connect the cantilever trusses.

On each side of this lofty hall is an annex 14 ft. wide formed by columns with arched aluminum extensions forming roof trusses *CA*, their heads being attached to the backs of the taller main columns. Thus the annex framing provides horizontal anchorage for the tall columns that carry the cantilevers. Purlins of 6-in. aluminum channels are framed between the columns and roof trusses, and at right angles to the purlins are the aluminum glazing bars, about 24 in. apart. These bars are either 2x1¼-in. flats or 2½x3x⅝-in. T-sections.

Subtropical Section—In this part of the building, along the main front, the roof, with about 50 ft. of headroom, is carried by triangular steel trusses of 46 ft. 6¾-in. span having curved or arched bottom chords. The street end of each truss is seated on the masonry wall, while the inner end is integral with a steel column. At the intersection with the end of the palm-house framing a special arrangement of steel trusses is introduced (Fig. 2).

Border Houses—This term is applied to the lower parts of the structure, forming the two sides and the rear portion. Here the roof, which gives an interior height of 20 ft., is carried by triangular roof trusses of 29-ft. span, *KA* (Fig. 4), having the outer or street end seated in the low masonry wall, while the inner end is curved and seated upon a steel column about 6 ft. high.

Fig. 4—Central centilevered dome and high- and low-roof portions of conservatory. Aluminum cantilevers and suspended trusses of palm house are carried by steel columns anchored against uplift. In border buildings triangular roof trusses are used, while arch trusses form the corner domes.



These roof trusses are of steel, but the purlins that they carry are 4-in. aluminum channels. At each rear corner this construction is modified by the introduction of a dome about 25 ft. high, with arched trusses, *NA* and *NB*, connected by lattice girders and supporting a rectangular monitor or ventilator. Diagonal bracing is introduced in four bays of the front and rear portions and in two bays of each side portion of the building.

Structural aluminum

Aluminum alloy was adopted mainly to reduce the cost of maintenance, cleaning and painting, especially in the lofty portions that are difficult of access and are subject to hot moist atmospheric conditions favorable to corrosion of steel. In the palm house the columns are of steel; the cantilevers, central suspended trusses and all purlins are of aluminum. In the two side bays of the palm house the curved heads of the columns are of aluminum, the columns being of steel. Aluminum is used also for some of the roof trusses in the lower parts of the structure. Sash bars or glazing bars are of aluminum throughout the building.

SPECIFICATIONS FOR ALUMINUM
Rolled Structural

	Purlins and Ridge Channels	Other Shapes, Plates, Rivets and Bolts	Glazing Members, Extruded	Cast Aluminum
Standard designation	4*S* ½ *H* (or ¼ *H*)	17*ST*	3*S* ½ *H*	43
Aluminum, min. per cent	96.0	92.0	97.0	91.7
Magnesium, per cent	0.9-1.4	3.5-4.5	....	....
Manganese, per cent	0.9-1.4	0.4-1.0	1.0-1.5	0.2*
Copper, max. per cent	0.2	3.5-4.5	0.2*	0.6*
Iron, max. per cent	....	....	....	0.8*
Zinc, max. per cent	....	....	....	0.2*
Tensile strength, min. lb.	25,000	55,000	14,000	17,000
Yield point, min. lb.	15,000	30,000	....	....
Elongation, min. per cent in 2 in.	15	16	18	3.8

*Maximum.

Two classes of rolled structural-aluminum alloy were specified as noted in the accompanying table, which also shows the specifications for aluminum glazing members and cast aluminum. For channels, which constitute the principal shapes, the sizes range from 3-in. depth with 0.17-in. web thickness and a weight of 1.46 lb. per foot, to 8-in. depth with 0.22-in. thickness and 4.08-lb. weight. The specifications provided that aluminum rivets be heated to 940 or 980 deg. F. and driven immediately with heavy pneumatic hammers, or preferably by the squeeze method. Aluminum members were assembled by service bolts, and the rivets were then driven at random to prevent drawing the parts out of position.

Welding was not used on the structural aluminum but only for aluminum in doors, interior fittings and roof sheathing. No paint or other coating is applied to aluminum, but where aluminum and steel are in contact both surfaces are given a shop coat of bituminastic paint. A field coat of the same material is applied to aluminum parts that will be embedded in masonry. Steel is furnished for use with the aluminum paint.

Aluminum sheets and rolled shapes are used for doors and for partition framing, while cast aluminum is specified for radiator grills and other interior fittings. Glazing bars or sash bars of aluminum are made by the extrusion process, as noted under glazing.

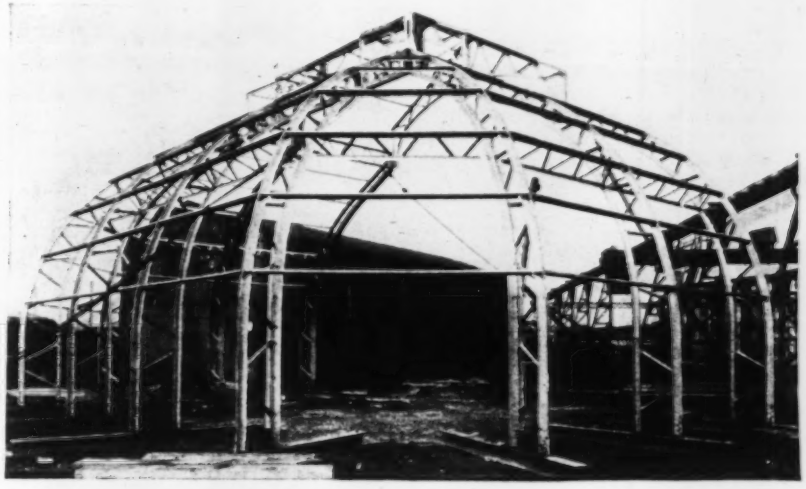


Fig. 5—Aluminum dome framing of palm house assembled at fabricating plant. Dome has a height of about 27 ft. and a diameter of 67 ft.

Loading

The structure was designed to resist a combined wind and snow load of 25 lb. per sq.ft., normal to the vertical and inclined surfaces. Snow in Washington is infrequent and rarely deep; also it will melt quickly on the warmed glass surfaces. The dead load of aluminum and glass roofing was taken as 4 lb. per sq.ft.

Aluminum fabrication

Fabrication of the aluminum material presented several problems. In most respects the aluminum compared favorably with steel as to its workability, but in other ways it was quite different, according to the fabricator. Handling it in the shop, due to the fact that its weight is but one-third that of steel, was easily accomplished, although as a matter of precaution ropes were substituted for chain in the hoist to avoid marring the surfaces that were to be exposed in the structure.

Shearing the aluminum was found to be impracticable inasmuch as a clean surface did not result. Accordingly, all cuts were made with a saw. Either a fine-set wood saw or a steel-band saw, such as is used on bronze or similar material, was found to be suitable for the purpose.

In punching, the cause of difficulty in shearing became somewhat of an asset. Thus in shearing the aluminum at ordinary room temperature it was found to break much more quickly than structural steel, and this characteristic resulted in very good punching action, due to the fact that the break occurred so early in the operation as to prevent distortion of the surrounding material.

Riveting the aluminum, using ¾-in.-diameter rivets throughout, offered the chief fabricating problem. Considerable time was spent in investigating and experimenting before the first production rivet was driven. Due to the close temperature limit permissible in handling the rivets, a special pyrometer-controlled furnace was devised for the purpose, which gave excellent results. The experimentation, however, did not disclose a suitable method for driving the aluminum rivets by hand, and compression riveting was used throughout the work.

Special precautions

In order that there might be no field alteration necessary on the aluminum dome it was assembled at the fabricating plant prior to shipment (Fig. 5). The freight on the aluminum material was considerable, since it was impossible to place enough fabricated aluminum trusswork in a car to meet the minimum demand of 30,000 lb. for a carload. Also, because of the relatively high cost of the aluminum, it was deemed desirable to carry insurance against fire, theft and damage or loss from the time that the material left the rolling mills until it was erected in the structure. As a further precaution against loss, all small pieces, such as short purlins, etc., were shipped in sealed boxcars.

In erection, except for the unique requirements of the structure and the fact that unusually precise work was

demanded, the aluminum offered no special problem other than the care in handling necessary to prevent mars or kinks.

Glazing and sash frames

Ground or ribbed white glass will be used for the exterior sheathing and roofing, with clear glass for interior walls and partitions. Both of these will be double-strength window glass of 26 oz. per sq.ft., made by the flat-drawn process. For curved surfaces the glass will be bent to the radii indicated on the drawings. Most of this glass will be in sheets 24 in. wide, with horizontal joints shingle-lapped $\frac{3}{8}$ in. It will be secured to the sash bars or glazing bars by wire or flat aluminum spring clips. Plate glass in doors, windows and partitions will be $\frac{1}{8}$ or $\frac{1}{4}$ in. thick. Hinged aluminum sash, fitted in horizontal rows, for ventilation and temperature regulation, are operated in sections by electric motors or by hand. Typical

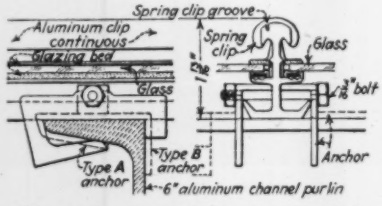


Fig. 6—Aluminum glazing bars are used in conservatory glazing. Most of the glass will be of 24-in. sheets with ⅜-in. lapped joints.

sash bar and glazing construction is shown in Fig. 6.

In the greenhouse portion of the building all gutters, sills, ridges, glazing bars, sash members and other parts supporting glass are to be of aluminum, formed by the extrusion process. They will be bolted to the aluminum purlins. Hips and valleys will be of welded sheet aluminum, embedded in mastic on closely spaced glazing bars and purlins. Steel and wood glazing bars are to be used in certain parts of the building, depending upon temperature conditions. Exterior and interior ladders and walkways are provided for cleaning and repair of glass and for access to sash-operating motors. No traveling cage or platform is provided for exterior cleaning.

Mechanical Equipment—Steam is to be obtained from an outside source at 50 to 100 lb. pressure and reduced to pressures of 2 to 5 lb. for the heating service, which is of the vacuum-return system, with automatic temperature control for the different sections of the building. Both radiators and unit heaters with fans will be provided. Water and drainage systems will connect with existing mains and sewers. For electric service 6,600-volt current will be delivered at the transformer room. Floodlighting for certain sections will be included in the elaborate lighting system. There will be 36 motors of 1 to $7\frac{1}{2}$ hp. for vacuum and condensate pumps, ejectors and air compressors, including 27 sash-operating motors of 1 hp. each.

Designers and Builders—This large conservatory building was designed under the general supervision of David Lynn, architect of the Capitol, by Bennett, Parsons & Frost, Chicago, as consulting architects, with Louis E. Ritter, Chicago, as structural engineer for the latter. The general contractor is the George A. Fuller Co., New Yor City. Steel and structural aluminu were fabricated and erected by th Wheeling Structural Steel Co., Wheel ing, W. Va. The glazing, with glazin bars and all architectural aluminu work, was let to the Lord & Burnha Co., Irvington, N. Y. The building wil be completed this summer at a cost o about $625,000, exclusive of land bu including mechanical equipment.

New Navigation Instrument Solves Spherical Triangles

Direct readings from arcs on three perpendicular axes of the "spherant" eliminate calculations in position finding

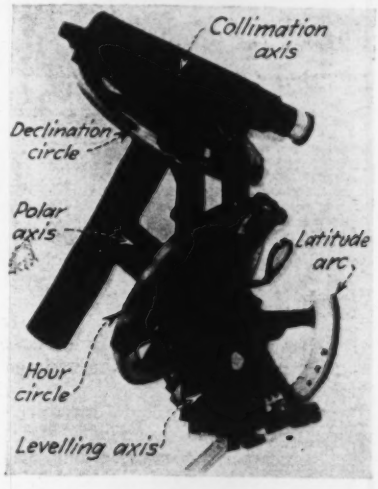
AN INSTRUMENT has been developed recently that breaks the 200-year-old tradition that a navigator, in order to determine latitude and longitude, must measure an altitude and then solve a spherical triangle. The new instrument accomplishes the solution of the spherical triangle mechanically. The "spherant," as it is called, is intended to obviate the work and the risks of error involved in using spherical trigonometry, logarithms and interpolation in complex tables. Instead, given the declination (taken from the *Nautical Almanac*) of the observed object, the hour angle for an assumed latitude, or the latitude for an assumed hour angle, may be read directly from the instrument, the spherical triangle having been solved mechanically during the process of making the observation.

The correct Greenwich time being known, the values read from the instrument may be converted into terms of position (latitude and longitude) by the simple operation of addition or subtraction. The only tables required are those found in the *Nautical Almanac*, and they are used only for taking out declination, equation of time and corrections for parallax and refraction. Corrections for index error, dip and semi-diameter are eliminated by the use of the spherant.

The principle employed in the instrument is the same as that used in the telescope mounting of most astronomical observatories, the novelty in the hand instrument being the practical means of casting the image of a fixed leveling device into the center line of a telescope, which is free to rotate about three mutually perpendicular axes. The operation might be likened to the use of a chain of three periscopes running through the pivot and the handle of the instrument.

The collimation axis of the telescope is perpendicular to and rotates about the axis of the declination circle. This axis is perpendicular to and rotates about the hour-angle arc or polar axis. And the latter, in turn, rotates about the leveling axis on which the latitude arc is mounted. The instrument may be leveled either by sighting on the horizon line or by use of a spirit level.

Advantages claimed include speed of



The spherant, showing the three mutually perpendicular axes and the three arcs that measure angles.

operation (which would make it particularly useful in aircraft), the elimination of errors resulting in mistakes in computation, and the fact that it makes possible the finding of latitude and longitude positions by a person who has not the mathematical training necessary to solve problems in spherical trigonometry. The instrument weighs about the same as the average sextant.

The spherant has been under development at the University of California for several years and is the work of Lieut. Howard B. Kaster, U. S. Naval Reserve, fromerly of the astronomical department, University of California.

Underpinning New York Post Office in Pennsylvania Terminal

Restricted work space and train movements made difficult work of introducing new two-column bents to permit lengthening train platforms—Welding used for girder stiffeners and for column bases

By Paul Penhune
Supervising Draftsman, Pennsylvania Railroad, Philadelphia, Pa.

AS PART of the Pennsylvania Railroad improvements in Pennsylvania Terminal, New York City, it was necessary to secure additional length of platform adjacent to the main running tracks, which previously accommodated fifteen-car trains, the added platform length allowing the operation of twenty-car trains. To accomplish this, the railroad engineers were faced with the serious problem of removing ten columns that supported the very heavy superstructure of the federal post office, which is an air-rights structure over the west end of the terminal. The loads on the columns that had to be underpinned and replaced by new steel ranged from 250 to 1,300 tons.

The existing column loads were picked up at two points of support as close to the existing columns as possible by means of silicon steel billets 5 ft. long and 16½ in. square, rolled from the ingot. A working stress of 24,000 lb. per sq.in. was used. Clearance limitations determined the 16½-in. depth, and silicon steel was resorted to in order to reduce the width of bearing, as it was feared that with wider billets the differential of deflection in the new girders at points on each side of the billets would produce uneven bearing. The silicon billets were supported in turn by two 50-ton girders parallel to the existing basement girders above, one girder passing each side of existing columns.

It was found necessary to splice these girders, as the maximum load that could be erected under the difficult working conditions and in the restricted space was 25 tons. The splices were made horizontally through the coverplates and chord angles, the box sections making a vertical splice impracticable. All steel was shop-assembled previous to shipment in sections. The arrangement of new steel is shown in Fig. 1.

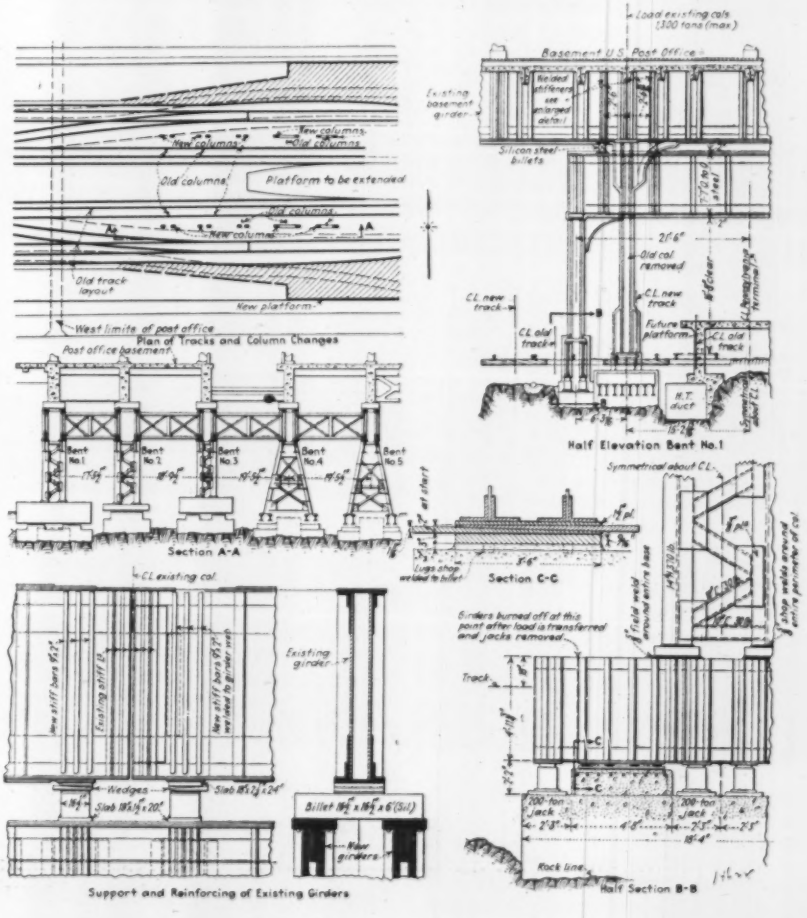
The new girders were supported on two-column bents with 6-in. slabs welded to the column bases in the shop, these in turn resting on two foundation grillages 60 in. deep running longitudinally between tracks. The design of the existing structure indicated a column load of 1,300 tons maximum, and hence eight 200-ton hydraulic jacks were provided under each grillage. Through wedges were used in conjunction with the jacks, as indicated in Fig. 1, and these were tapped in after each increment of pressure and were finally driven in tight and welded in place at the completion of the work. In order to secure bearing between old and new steel before the jacking took place, shims and wedges were introduced over the silicon billets, and considerable adjustment was necessary in order to bring the old and new surfaces into parallel contact. The concrete foundations were on rock, which eliminated any possibility of settlement.

The erection of these new girders in the short intervals between trains necessitated special equipment due to the close clearances between existing columns and girders under the basement floor. Strain gages were attached to all faces of new and existing columns, and all readings together with pump pressures agreed within close limits. An organization was set up to control the jacking operation, and four men with two levels posted within the basement floor of the post office in a section remote from the jacking operation noted any rise in the first-story columns and communicated directly with the control men below.

In order to keep the operation well under control, pressure on the pumps was applied in increments of 300 lb. per sq.in., or about 60 tons, an interval of 3 min. being allowed after each pressure increase to record and coordinate strain-gage readings, etc. The accompanying tabulation gives the results.

Welded Stiffeners — The reinforcement of the existing girders at the new points of support was accomplished by introducing 9x2-in. stiffener bars, beveled to facilitate welding, as indicated in Fig. 1. Because the existing girders were of box section, no alternative to welding presented itself. In order to install these new stiffener bars it was necessary to burn them in the

Fig. 1—Details and layout of underpinning by which five pairs of columns supporting New York post office were removed to provide increased platform and trackage space below.



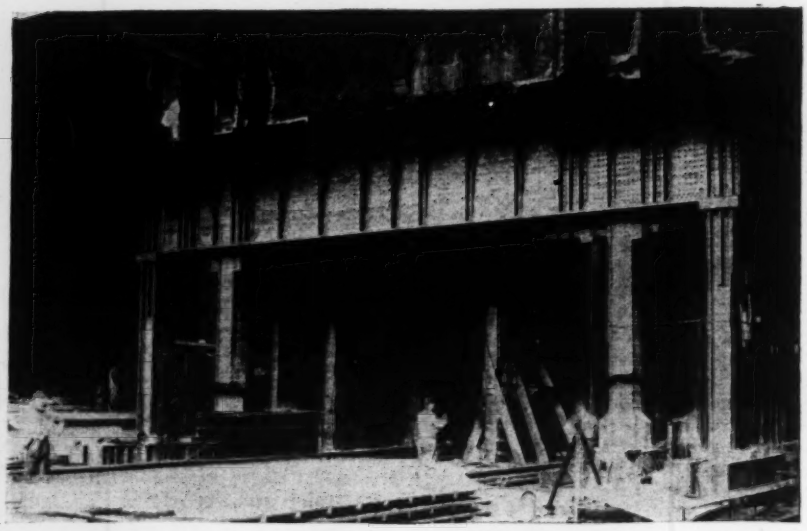


Fig. 2—Underpinning bent supporting New York post office over Pennsylvania Terminal, showing old columns in course of removal. View is of bent No. 1.

shop to fit over rivet heads and side plates so as to come in close contact with the web.

The bars were spaced 4½ in. apart and were fabricated ½ in. short, being wedged up at the bottom when erected. A continuous ½-in. weld was applied to the web for the full length of the bar on both sides, and the space at the bottom was entirely filled in with weld metal to insure good bearing.

Personnel—This work was in charge of A. C. Watson, chief engineer, New York zone, Pennsylvania Railroad, the work being executed under the direction of T. W. Pinard, engineer of bridges and buildings, and E. L. Goldsmith, supervisor of construction. The firm of Moran & Proctor, New York City, was consulting engineer, while Gibbs & Hill, Inc., was the general contracting firm.

Cylinder Underpinning Checks Sinking Foundation

Supports at critical points expected to check rate of settlement until consolidation of ground brings building to rest

By Harry Spillman

Plant Maintenance Engineer, Continental Motors Co., Muskegon, Mich.

SETTLEMENT began immediately after the completion of the 40,000-kva. power plant of the Continental Motors Co., at Muskegon, Mich. Sinking progressed until it had reached 15¼ in. at the point of greatest settlement and 3⅛ in. at the point of least settlement. The varation in rate of settlement between the two extremes was very uniform, and the building showed no signs of distress in any part. It was decided, however, inasmuch as the settlement-time records showed no indication of any decrease of rate of settlement, that steps be taken to stop this movement before it became sufficient to damage equipment or to overstress the superstructure.

Fig. 1 shows the plant, with Muskegon Lake in the background. The main equipment consists of four 5,000-kva. turbo-generators and eight 1,000-hp. boilers. There are two brick-lined steel stacks 175 ft. high carried on heavy girders at the roof level. The boilers are on the second-floor level, and standard-gage railroad cars operate on the first-floor level for ash handling. The boilers are supplied with fuel from overhead bunkers, so that the entire weight of the structure and equipment is carried on the steel frame. The column loads are about 440 tons each. The natural ground is only 4 ft. above lake level, and the first floor is at grade. There is no basement except the coal-handling pit.

The foundations are six continuous concrete footings supported on piles, each footing extending the full width of the building parallel to the shore. The footings were braced by struts at frequent intervals, leaving open pockets between struts and footings.

On and adjacent to the site there was at one time conducted a logging and lumber industry. The lumber slabs, sawdust and other refuse were dumped into the lake, and the borings show depths up to 18 ft. of such material. At recent date the made ground was formed by dredging, the materials being fine sand and silt.

Tests indicated a safe pile load of 30 tons, but 16 tons was the maximum used in the design. This assumption called for about 2,000 piles on spacings varying from 2-ft. to 3⅔-ft. centers according to column-load variations. The average was probably about 2¾ ft. The piles were driven with a 2,200-lb. drop hammer, and all were driven to a penetration of ¼ in. under the hammer, falling 50 ft. The piles were planned to be 40 ft. long. Due to the close spacing and the comparative incompressibility of some of the material as the driving progressed, the piles reached the assumed penetration at lesser depths than anticipated, and considerable lengths were cut off.

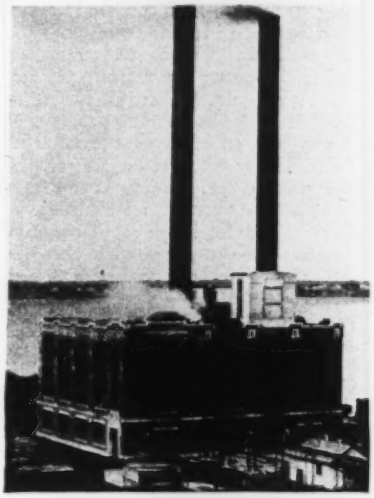


Fig. 1—Power house threatened by tilting settlement from 3 in. at rear to 15 in. at lake front.

Underpinning plan

The settlement was greatest at one of the corners toward the shore. The columns with the greatest load did not show any greater rate of settlement than those of lesser loads, so that it was apparent that the foundation-girder system was equalizing the movement.

The first step in the investigation was a recheck of the design of the pile and foundation members, and all were found to be correct in accordance with the original assumptions. A series of borings showed, in general, fills of various sorts, including sawmill refuse, to a depth of 45 ft. Below this is sand and clay to a total depth of 75 ft., and below this is hard clay.

As a result of the investigation, it was decided that the primary cause of the settlement was the use of piles on

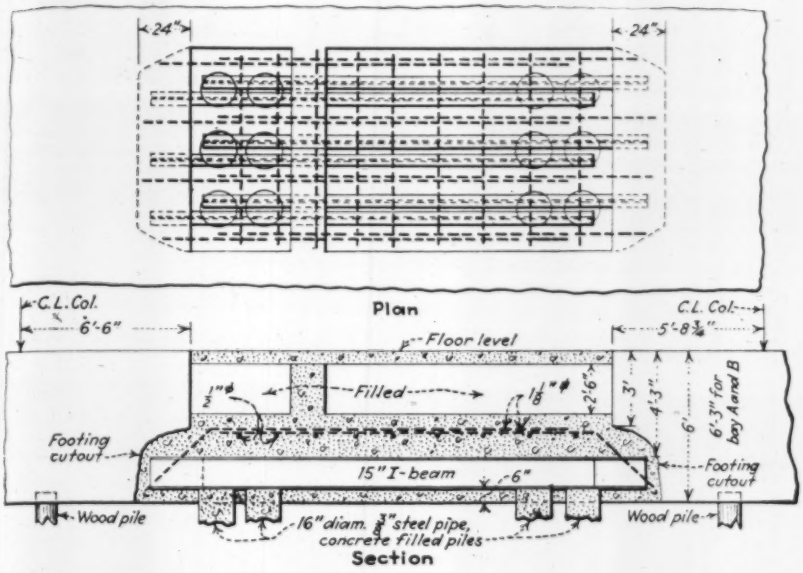


Fig. 2—Typical underpinning structure installed between column footings.

too close centers. The piles in the test that was the basis of the design were driven on 8-ft. centers, while those in the work were on 2½-ft. centers.

After considering various methods of increasing the support of the footings it was proposed to drive in the open spaces in the foundation system 16-in. open-end cylinders, extending into firm material. These were to be blown out and filled with concrete. The load was to be transferred to these cylinders by reinforced-concrete caps. It was thought that this type of support would arrest the settlement without providing underpinning for all of the structure. About one-half of a complete underpinning operation was contemplated, with the idea that additional portions of the building could be underpinned later if necessary. Space was provided for a possible pneumatic cylinder in case the underpinning at any place proved ineffective. Fig. 2 shows a typical underpinning structure filling one of the pockets between footings and struts.

Methods and results

The underpinning was completed in 170 days under cramped working conditions. The average length of the cylinders was about 75 ft. Because of restricted headroom the length of cylinder sections was limited to about 10 ft. The sections were joined with internal connecting sleeves, with shoulders projecting to the outside diameter of the pipe. These were made to a driving fit and were watertight. After the cylinders in any group were driven to the required depth they were excavated by compressed air jets and filled with concrete. During the driving a few cylinders were stopped by obstructions of various sorts, principally heavy timbers, and were replaced by others driven as close as possible thereto.

After the cylinders were driven, each was tested to a predetermined overload and wedged against the supported structure by the pretest method without releasing the test load. The cylinders were tested in this manner singly and in groups. By this method it was certain that all cylinders would be of equal carrying capacity and sufficient for the assumed load. It was not intended that this work would stop the settlement of the points underpinned, because such an event would be likely to cause damage, due to continued settlement of parts not underpinned. It was expected that the work done would retard the rate of the settlement and that the structure would in time come to rest. Observations taken since completion of the work show that the rate of settlement is gradually decreasing, and at some of the observed points has stopped.

The Spencer, White & Prentis Co., of Detroit, Mich., were the originators of the plan adopted, and the work was performed by them.

New Set of Standard Engineering Symbols

SYMBOLS for use in the field of mechanics, structural engineering and material testing have been approved by the American Standards Association. The list of symbols was prepared by a special committee of the association, which was organized in 1926. It had the joint sponsorship of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Association for the Advancement of Science, the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers. The chairman of the committee was John T. Faig, president, Ohio Mechanics Institute, Cincinnati, Ohio. Copies of the standards can be secured from the American Standards Association, 29 West 39th St., New York, N. Y. The list follows:

Acceleration, angular	α (alpha)
Acceleration, due to gravity	g
Acceleration, linear	a
Angular distance	θ (theta)
Angular velocity	ω (omega)
Area	A
Axes, through any point	X-X Y-Y Z-Z
Breadth	b
Center of rotation	O
Coefficient of sliding friction	f
Concentrated load (same as force)	F
Constants	C
Curvature, radius of	ρ (rho)
Deflection	y
Deflection of a panel point of a truss	Δ (delta)
Density	ρ (rho) or d
Depth	d
Diameter	D
Distance, linear	s
Eccentricity of application of load	e
Efficiency (hydraulic, mechanical, volumetric)	e_h, e_m, e_v
Elasticity, modulus of	E
Elongation, unit	δ (delta)
Force	F
Force in any bar of a framed structure due to a load of unity applied at any point in any direction	u
Frequency (harmonic motion)	f or n
Gyration, radius of	k
Head	H or h
Height	h
Inertia, rectangular moment of	I
Inertia, polar moment of	J
Length	L
Load per unit distance	w
Load, total	W
Mass	m
Modulus of rupture	R
Moment (in.-lb.) at any section of a girder due to the moment of 1 in.-lb. applied to the girder at any point	m
Moment of force, including bending moment	M
Neutral axis, distance to extreme fiber	c
Number of revolutions per unit of time	n
Period (harmonic motion)	T
Power, hp	P
Pressure per unit of area	p
Radius	r
Ratio between elastic moduli of steel and concrete	n
Ratio of the distance from the neutral axis to the outer fiber of a reinforced-concrete beam to the distance from the outer fiber to the point of application of the resultant tensile stress	k
Ratio of the lever arm of the resisting couple in a reinforced-concrete beam to the distance between the outer compressive fiber and the point of application of the resultant tensile stress	j
Reactions	R
Section modulus	Z or S
Statical moment of any area about a given axis	Q
Steel ratio, in reinforced-concrete beams	p
Stress, unit	s
Stress, unit compressive	s_c
Stress, unit tensile	s_t
Stress, unit shear	s_s
Stress, total tensile or total steel, in reinforced concrete	T
Stress, total compressive or total concrete, in reinforced concrete	C
Stress, total shear	V
Stress, unit concrete, in reinforced concrete	f_c
Stress, unit steel, in reinforced concrete	f_s
Stress, unit shear of concrete	v
Temperature, absolute	T
Temperature, ordinary	t
Thickness	d or t
Time	t
Torque	T
Velocity, linear	V or v
Volume	V
Work, or energy	W

New York Subway Construction—VIII

Underpinning a Subway Crossing

In constructing new subway beneath existing line, pipe piles aggregating nearly five miles in length were jacked down to support the existing structure and to serve as foundations for new line

By Irving Troemel

Assistant Section Engineer, New York Board of Transportation

PREVIOUS ARTICLES in this series devoted to construction of the new independent system of New York subways have, for the most part, dealt with general conditions and problems applicable to the whole system. Difficult and interesting construction problems are encountered on nearly every subway contract. The handling of several of these difficult situations will be described from time to time. The following article tells of the underpinning of the B.M.T. Centre St. loop at Delancey St. to permit the passage of the new Houston-Essex St. line underneath. Previous articles in this subway series have been published Aug. 7, 1930, p. 200; Sept. 4, 1930, p. 371; Sept. 18, 1930, p. 455; Nov. 20, 1930, p. 796; Jan. 26, 1931, p. 136; Dec. 24, 1931, p. 1,000; and March 31, 1932, p. 471.

—EDITOR.

A TOTAL of 26,000 lin.ft., or nearly 5 miles, of pipe piles were jacked down inch by inch as underpinning for the existing Centre St. loop structure of the New York Rapid Transit Corp. (B.M.T. lines) at Delancey and Essex Sts., Manhattan, to permit the Houston-Essex St. line of New York City's new subway system to cross underneath. At the crossing the new subway is a two-track station structure with side platforms having a width of about 140 ft. Subgrade is about 45 ft. below street surface. The Centre St. loop structure at this point is a double-track station with one island platform, one side platform, and a wide unused area averaging 110 ft. in width. Traffic on this line is very heavy.

The supporting of the B.M.T. was a difficult problem because of the size of the structure to be carried, the nature of its construction, the character of the underlying material and the presence of groundwater about 2 ft. above the invert. The old subway was built in two sections: the east half about 25 years ago along with the Williamsburg Bridge for trolley use; the west half about 20 years ago for rapid-transit purposes. Furthermore, the west half was altered twice after construction, once to relocate tracks and again to lengthen the north platform. The east half is a steel-bent and concrete structure resting on grillages and concrete footings. Side-wall columns are spaced 3 ft. c. to c. with concrete arches between. The interior columns are spaced 12 ft. c. to c. and carry longitudinal girders that support transverse roof beams spaced 3 ft. c. to c. Part of the west half is made up of the New York subway standard steel-bent construction, 5 ft. c. to c., with concrete jack arches. The platform portion of the west half consists of side-wall columns spaced 5 ft. c. to c. and interior columns irregularly spaced, carrying longitudinal beams to support the roof. This entire portion rests on a 12-in. slab of unreinforced concrete. Its irregular and reconstructed make-up made it impossible to place much dependence upon the stiffness of the structure. Also, the ground underneath was a water-bearing sand fine enough to run through any sheeting not absolutely watertight.

The method finally adopted for the construction of the new subway avoided the necessity of entering or doing any work within the old subway under operation. In brief, it consisted of drifting and widening out a gallery 6 ft. high under the B.M.T. invert to permit the installation of steel runner beams, parallel with the center line of the new subway, to carry the old structure; jacking steel pipe piles to a grade below the new subway invert for the support of these beams; and the building of the new structure and removal of temporary supports.

The new subway construction to the north and south of the crossing was in the usual sheeted-trench horizontal sheeting, vertical H-beam posts being used (*ENR*, Sept. 4, 1930, p. 371). The first main cut was made down to groundwater, which brought the excavation close to the invert of the B.M.T. crossing. Sumps were then sunk along the line to within 30 ft. of the structure. Excavation on both sides of the B.M.T. structure was gradually carried to subgrade to points just outside the last sump. At these two points timber bulkheads were erected to support the banks until underpinning operations secured the subway structure. Pumping was carried on in these sumps while the main subway construction advanced toward the bulkheads. Both operations helped to lower the groundwater level.

The north platform of the B.M.T. was about 5 ft. above the level of the main invert, thus making it necessary to pick up this platform before proceeding with the main structure. This was done by driving small drifts to t south side of the platform and installi 14-in. beams placed transversely at 5-f intervals. These were posted tempo rarily to the bottom of the drifts. Tw continuous beams were then placed, on under each edge of the platform. Thes beams were then carried on temporar underpinning piles jacked below th level of the future main drifts.

Procedure

The first step, that of providing working gallery, was done by drivin drifts under the subway. The firs

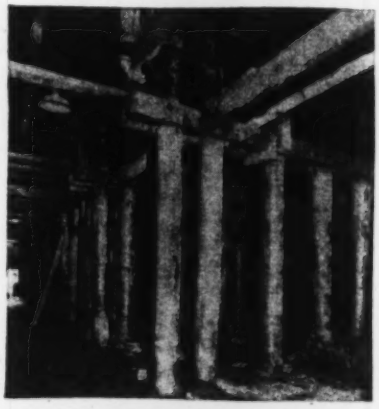


Fig. 1—Steel pipe piles underpinning B.M.T. subway for construction of new Houston-Essex St. line crossing.

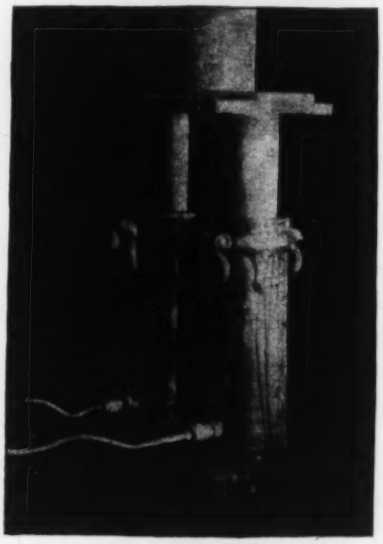


Fig. 2—Pair of hydraulic jacks driving one of 16-in. pipe piles.

drift, 8x9 ft., was located on the center line of the new subway and was started from both sides of the B.M.T. Excavation was carried ahead in 5-ft. steps, the invert of the B.M.T. spanning this gap until shoring was set in place. As the excavation was carried down, 2-in. horizontal side and heading

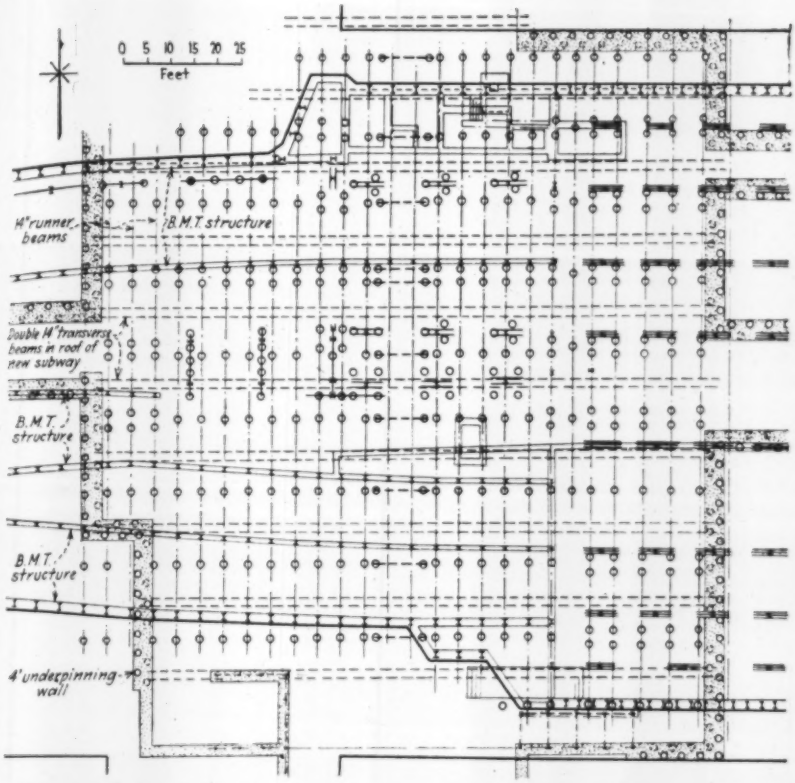


Fig. 3—Floor plan of B.M.T. structure at crossing of new subway, showing location of underpinning piles. Dotted lines indicate position of runner beams placed below B.M.T. invert, also transverse beams placed later as part of new subway roof steel.

sheeting was carried with it, care being taken to pack carefully behind each plank. As soon as the excavation reached the bottom of the drift, temporary shores were placed under columns, walls and running rails (Fig. 5). Some groundwater was encountered, making it necessary to provide a subdrain. This drain was kept up close to the heading to keep down the groundwater, which showed up as high as 3 ft. on the face of the heading. As soon as the drain was laid, 4-in. blocking was placed on the bottom of the drift and the shoring posts were set up. Before any post was set its foot block was loaded by means of hydraulic jacks, and before the jacks were released the post was wedged into place with steel shim plates. This procedure prevented any settlement of the B.M.T. subway structure. To provide a good bearing for the posts and also to afford bearing for the future runner beams, ¾-in. steel plates were dry-packed in place against the roof before the posts were loaded. To these plates were welded angle irons to keep the posts in place. When this drift was well under way, two other drifts were started, one located 35 ft. east and one 37 ft. west of the center.

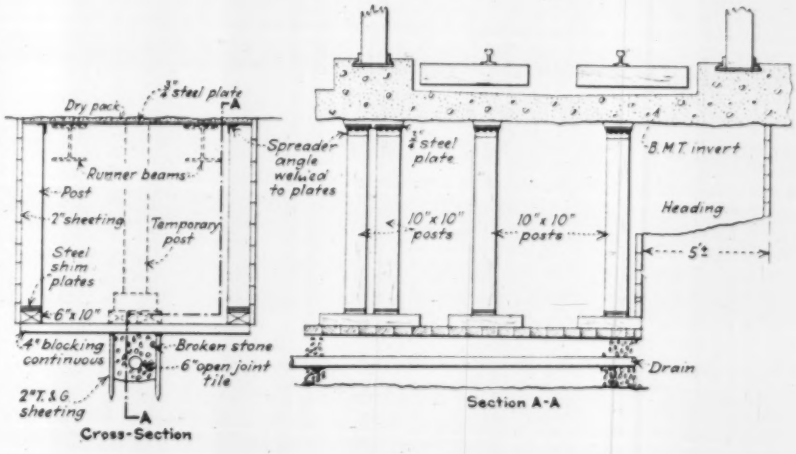
The same method was used in carrying the other two drifts through and proved satisfactory for areas where only walls and columns 5 ft. apart were to be supported. This method, however, was not used for isolated heavily loaded grillages. These were taken care of by making lateral drifts from one of the main drifts and by picking up the grillages on piles directly. This was done by excavating under a part of the grillage and sinking the pile at once and continuing this process until the entire grillage was carried. In areas where no heavily loaded grillages were encountered, the gallery was widened by driving a drift parallel and adjacent to the existing drift.

Before too great an area was exposed it was necessary to proceed with the second step—placing the longitudinal or runner beams—for they added greatly to the rigidity of the structure. These were a system of beams roughly parallel to the center line of the new subway, spaced 5 ft. c. to c., and placed directly under the B.M.T. bents. The beams were 14-in. sections, varying in weight from 135 to 225 lb. per foot, shipped in three pieces in order to facilitate handling, provision being made for full strength splices. They were rolled in by hand, jacked up to bear on the ¾-in. plates already placed and were posted to the bottom of the drift. In jacking these beams into position a very effective scheme was used. Several hydraulic jacks were set up under the beam, spaced so as to take care of the entire length of the beam. When pressure was applied the whole beam was lifted about 12 in. and blocked up, and the process was repeated until the beam was up in place. All void spaces above the tops of the beams were then dry-packed. As these beams were to form a part of the permanent roof of the new subway, it was necessary that their grade be carefully checked.

Piles carry runner beams

The third operation, that of jacking the piles to carry the load from the runner beams to the new subgrade, was now started. With the beams for a reaction, 4-ft. lengths of 16-in. steel pipe were jacked to 20 ft. below subgrade and filled with concrete. Four ½-in. rods were used as vertical reinforcing. The piles were jacked down, two 4½-in. rams being used on each pile (Fig. 2), and hydraulic pressure being supplied by a central pump automatically controlled by a hydro-pneumatic accumulator. At the start of the job cold weather was encountered, and a small steam boiler was installed to keep the water in the hydraulic line from freezing. In order to speed the operation of piledriving, short sections of heavy steel tubing, in lengths from 2 in. to 2 ft. with milled ends, were always on hand to be used as blocking above the

Fig. 4—Method of driving drifts for excavation of gallery beneath B.M.T. subway invert.



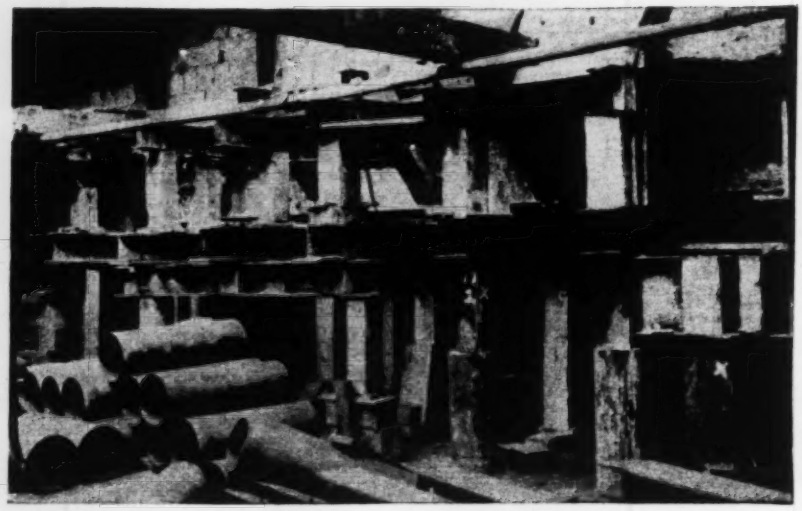


Fig. 5—View at north wall of B.M.T. structure after gallery had been excavated. Upper beams are carrying B.M.T. platform, lower beams are 14-in. runners forming main support of old subway structure.

jack. This no doubt prevented many an accident that might have resulted from jacks kicking out because of improvised blocking.

At first, orange-peel buckets were tried for cleaning out the pile, but these proved too slow. A compressed-air jet was finally adopted and did the work satisfactorily. At the start trouble was caused by water and sand leaking in at the joints of the piles. This was stopped by wrapping a length of weather stripping around the collars before the next length was inserted. Another source of trouble was the boiling of the material in the bottom of the pile caused by the head of water, which was undesirable, for much loss of ground would cause settlement of the posts and the runner beams and also settlement of any completed piles near by. The boiling was eliminated by leaving a short length of the pile unexcavated and placing the concrete in the pile immediately after it was cleaned out. When the concrete had set, the pile was jacked to about 100 tons and held until settlement ceased. Another length was then added and a beam concreted into the top, as may be seen in Fig. 1. When this concrete had set, the pile was then jacked to about 75 tons and wedged against the runner beam before releasing the load. The designed load on these piles was about 50 tons. Along the center line of subway, in order to give working room, two runner beams were carried on cross-beams 10 ft. long supported by piles under each end.

The old structure was now carried on a system of beams resting on piles driven below the future subgrade. Main excavation was started by lowering the wide drift on the center line of the subway and later widening out on both sides. Digging was done by hand because of the cramped quarters. Quite a bit of water was encountered as the excavation deepened. Material was cast out from under the structure by a chain of belt conveyors and was raised to the street by a clamshell bucket. This work could not be pushed too fast, as the material would boil if not given sufficient time to drain. When a group of piles was exposed they were braced with 6x12-in. struts. As grade was reached in the center, subdrains were installed 4 ft. below subgrade. These consisted of 6-in. open tile laid in gravel running to a sump. Side drains radiated from the center drain and helped lower the water over the entire area.

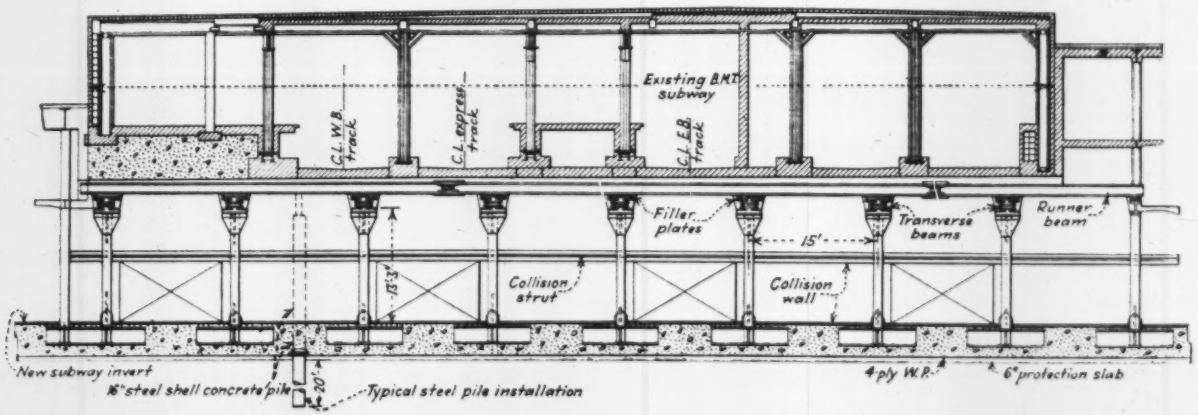
Great care had to be used in excavation at the side walls to prevent a loss of ground and consequent settlement of the structure above, outside the supported area. By the time this part of the work was reached in taking out the first lift, the water was below the area disturbed, so no trouble occurred in placing the side sheeting, which was braced against posts wedged to the old structure invert. Any voids behind this sheeting were filled and tamped. A row of piles was then packed down close to the outside face of the future subway wall and wedged to the invert above. These piles were later used to brace the sheeting as it was placed. In going down at the side walls it was imperative that the water level be lowered previous to the placing of the side sheeting. This precaution can be appreciated when it is remembered that the sand was so fine that any sheeting that would not hold water would not prevent the wet sand from running through. When this sheeting was in place another row of piles just inside those already in place was driven for additional support of the side retaining walls.

It was planned that the underpinning piles, extending 20 ft. below subgrade of the new subway, would be cut off at invert level and act as foundation piles to the new structure. In addition to the 460 underpinning piles, 260 more were driven to provide additional foundation support. In all, about 26,000 lin.ft. of 16-in. piles was driven, 20,000 lin.ft. being left in place. Of this large number of piles none was much out of plumb or seriously distorted.

Fig. 6—Longitudinal section of new subway and cross-section of old structure. Piling installation is indicated but not shown in full. Underpinning piles were cut off at top of new subway invert to serve as foundation support.

New construction

The first step in the actual construction of the new subway structure was



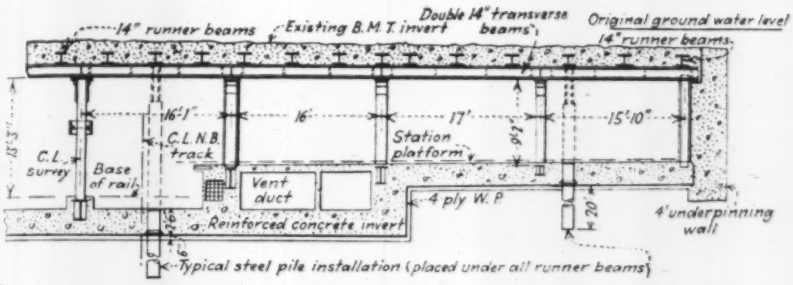


Fig. 7—Half cross-section of new subway, showing how runner beams were incorporated into permanent roof steel.

to cover the foundation area with a 6-in. concrete slab. This slab was merely to provide a surface for applying the waterproofing of the new subway invert. Inasmuch as the underpinning piles were to be cut off later at the tops of the new subway invert, it was necessary to provide some means of preventing leakage through the invert around the piles. This was accomplished by welding angle-iron flanges around each pile about 1 in. above the waterproofing mat. These flanges also added to the bearing ability of the piles acting as foundation support for the new structures. The next step was to pour the 4-ft. structural mat comprising the invert of the new subway. After the invert slab was complete, the next operation was to place the permanent steel.

The center beams used in the underpinning comprised the roof steel of the new structure. As steel erection with any kind of a derrick was impossible, because of interference with the underpinning piles, a stationary air hoist was rigged up to aid in handling the steel. The steel was brought into the underpinned area on a small car equipped with a turntable operating on a narrow-gage track. The air hoist was then used to drag the steel to final location. First the grillages supporting the columns were placed, next the transverse beams were hung to the runner beams with temporary steel hangers. The columns were next erected, and the transverse beams were lowered onto the columns, leaving a space between these beams and the bottom of the runner beams. This space, varying from 1 to 6 in., was filled with plates giving full bearing between the two sets of beams. Transfer of the roof load to the columns was accomplished by jacking from the grillage to the cap plate of the columns and driving a shim between the bottom of the column and the grillage. The columns were jacked to about one-half design load.

With the permanent columns firmly wedged in place and carrying part of their load, it was now possible to remove the lengths of underpinning piles above the invert. The first operation, after removing the bracing, was to flame-cut at an angle the beam embedded in the top of the pile. Next the steel shells of the piles were cut at the top of the invert. The concrete columns inside the pipe shells were broken off at the invert by hooking a cable to the top of the piles and pulling them over with a hoist.

The next operation was to concrete the roof slab of the new subway. As this could not readily be done by gravity, a pneumatic concrete-placing machine was used. After some experiment it was found that an area 5x45 ft. could be blown with one pipe. A 6-in. steel pipe was run to the center of the panel of this size and left in place. The force exerted by the concrete impelled by 60 lb. of air was realized when it was discovered that the entire roof panel was squeezing into the 6x6-in. posts used as form supports. The number of posts supporting the roof forms were doubled to stop this trouble. Another instance of the force created by the impact of the concrete was shown when one of the runner beams on the side of a panel being poured moved sideways, although it was carrying its share of the load of the subway above. Thereafter all beams at the side of a panel were shored to the next beam with steel struts.

During the transfer of load to the permanent steel columns, readings with a strain gage were taken on the columns at various stages of the work. It was found that the effect on the columns when the piles were removed was irregular, presumably due to the flexing of the continuous runner beams and also to the fact that it was entirely possible that some piles carried much greater loads than others. The loads obtained when the roof was finished were usually found to be below the design load. This evidently was due to the difference between the assumed live load and the live load actually on the structure when the reading was taken. An interesting fact noted was that even though a train was passing directly overhead no appreciable change in loading occurred, although load changes as small as 10 tons were easily detected by the readings. The only reasonable explanation of this is that the roof was so stiff that it spread the load over many columns and that the change in load on each column was too small to be detected.

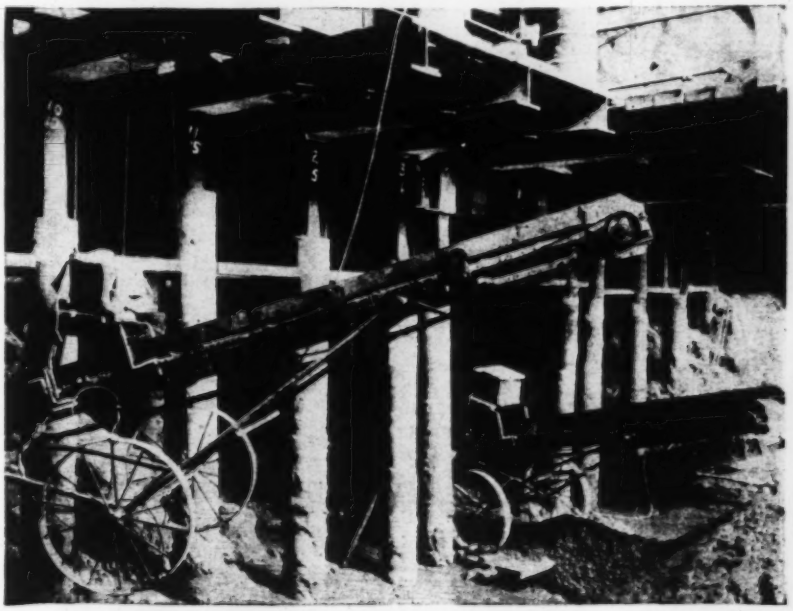


Fig. 8—Portable belt conveyors were used in removing excavation.

The new subway is part of the independent system being built by the board of transportation of New York, under the direction of Robert Ridgway, chief engineer, and J. R. Slattery, deputy chief engineer in charge of construction. J. O. Shipman is division engineer, C. A. Hunt subdivision engineer, and A. B. Malcomson section engineer in immediate charge of the work. The Corson Construction Corp., New York, is contractor, with George Paaswell, chief engineer, in charge. Spencer, White & Prentis, Inc., New York, acted as consulting engineers to the contractor.

Subgrade Design by Soil Surveys in Michigan

Soil inspector directs grading operations by soil survey preceding construction and frequent inspection of material disclosed by grading cuts

WITH DATA accumulated from eight years of general soil studies and special studies of frost action and swamp soils, the engineers of the Michigan highway department have developed a practicable procedure for designing subgrades based on soil character. This procedure, which is believed to be simple and certain, is briefly outlined in the following extracts from a paper by A. C. Benkelman, research engineer, Michigan highway department. It was read at the annual conference on highway engineering of the University of Michigan, Feb. 16, 1932. —EDITOR.

THE KNOWLEDGE of soil performance in terms of pavement behavior, acquired from extensive soil studies together with supplementary knowledge obtained from laboratory investigations of frost heaving, constitutes the background on which the design of subgrades on new construction work is based. The knowledge gained from the investigations indicates that it is possible in the great majority of cases to recognize, by visual inspection, those conditions of subgrades, types of soil, abrupt local changes in soil texture, etc., which are the cause of serious trouble.

Frost action is by far the most destructive agency as far as rigid pavements in Michigan are concerned. In fact only minor pavement cracking or breakage has been observed to occur during the summer and fall period. In addition to the problem of frost-heave correction, considerable more attention is being paid to the proper utilizaton of the soil materials available for the construction of fills as well as to the methods of construction used. The extent of damage to rigid pavements caused by lack of fill consolidation and of uniformity in many of our older pavements approaches that due to frost action.

Applying soil knowledge

In the application of the knowledge of soils to the construction of new roads a definite procedure has been evolved. Written instructions were prepared for distibution to the field engineers as well as to the personnel of the road-design division of the department. These instructions, or design recommendations, list data pertaining to each of the individual soil types existing in the state. A vertical section of each soil profile is shown, on which the various layers and their character and thickness are indicated. In addition, definite information is listed as to where the grade line of the road should be established in order to avoid inferior material or to avert or relieve bad conditions of drainage. Instructions are also given as to the relative suitability of the different materials in the soil profile for the construction of fills, including when and how the fills should be made. Incidentally, this information assists greatly in locating suitable borrow material where this is necessary.

The order of procedure calls for a preliminary soil survey immediately after the initial construction survey is made. When the plans are drawn up the grade line is established as closely as possible in accordance with the recommendations. The soil types are indicated on the plans, permitting the field engineer, as well as the contractor, to utilize the information furnished them. As the grading operations progress, the soil inspector visits the job as often as it becomes necessary to examine the cut sections thoroughly and completely as they are opened up. His knowledge of the various soil types enables him to devote more time to areas in which questionable material or conditions are apt to be encountered. In special cases he develops profile sketches showing the exact location of undesirable material requiring excavation or indicating the location of impervious layers of soil with respect to the finished grade. Elaborate profile sketches are, however, the exception rather than the rule.

From notes on borings the inspector is able in many cases to render a decision on the spot. This, in the case of removal of frost-heave material, eliminates the cost incident to moving heavy equipment back to the location in question at a later date. In many cases where removal of undesirable soil textures is necessary, a suitable backfill may be obtained generally in the same cut; and if such deposits are located soon enough, the only cost involved is that of excavation. It is not felt that it is necessary to import a material for backfilling; usually a soil texture is used, similar to that existing on either side of the location in question. It should be definitely understood that the soil man does not act simply in an advisory capacity. His recommendations are accepted without question and generally executed without serious delay.

Many of the project engineers have manifested an unusual interest in the soil work. It is extremely questionable, however, if the engineer will ever be expected to handle the soil-inspection work in addition to his other duties. It is felt that such work requires at least several years of experience and constant application if any great measure of success is to be attained, and moreover it would demand too much of the engineer's time.

The soil personnel of the department, at the present time, consists of five full-time men. The chief of the staff reports directly to the engineer of design, at the same time maintaining a working contact with the divison, research and construction engineers. He assigns the various grading projects to the different men, handles necessary correspondence, keeps detailed records of the progress of the work and in many cases assists the other soil men where unusual conditions or problems are encountered. In addition, he has certain other duties in connection with the sounding of peat marshes and boring of fills at such locations after they are completed.

Cost of soil inspection

During the past year some 500 miles of grading work was inspected by this staff of soil men, the average cost per mile being about $25. This, it is felt, constitutes a very reasonable expenditure for this work. Some consideration is now being given to the proposal of assigning a soil man permanently to each of the five construction divisions in the state. This would tend toward a further reduction in the cost of inspection, besides enabling each man to become more familiar with the problems in his particular assigned territory.

Extensive Reconstruction for City of Canton, China

The municipality of Canton, China, has appointed a special commission whose purpose is to divide the city into fifteen zones and to institute improvements in these zones successively, according to report to the Department of Commerce by J. W. Ballantine, consul general there. In the first zone of which work is to be started it is planned to provide for the construction of a number of avenues of a uniform width of 80 ft., flanked with 12-ft. sidewalks and lined with shade trees.

Buildings more than five years old are to be demolished or reconstructed within two years, so that all buildings in the zone may conform to the plan of the commission. Mortgages will be arranged by the municipality for property owners who lack the necessary capital to finance new construction. Each two years a new zone will be handled in the same way, so that the entire program will spread over a period of 30 years. It is planned to meet reconstruction expenses by loans, which it is thought can be raised if the program meets popular requirements.

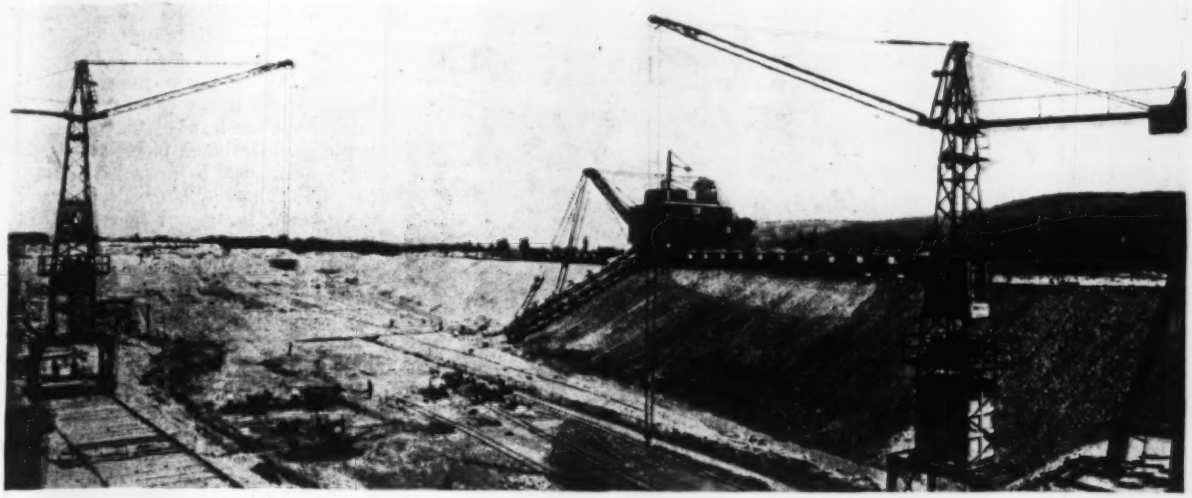


Fig. 1—Finishing the canal slope was done by excavators designed for that purpose. Large revolving cranes served the men doing other grading work.

First Section of New Canal on Rhine Nears Completion

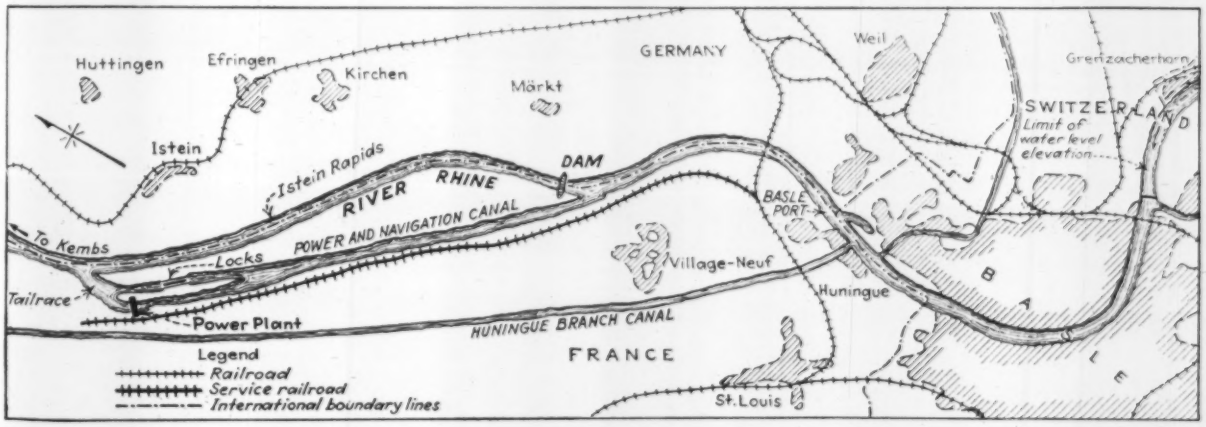
International navigation and power scheme ultimately will open the upper section of the Rhine River to modern barges from Strassburg to Basle, a distance of 136 miles—Large amount of power to be developed

THERE IS now nearing completion in the Rhine River valley below Basle, Switzerland, a navigation canal and hydro-electric power plant, which ultimately will form the upper section of a power and navigation development of the entire river from Basle down to Strassburg where the Rhine-Marne canal comes in, a distance of 220 km. The canal is known as the Grand Canal d'Alsace. It will be, in part, a lateral canal replacing the present river channel as a navigable route, a lateral type of canal having been adopted to facilitate the economic development of power. Ultimately there are to be eight hydro-electric plants, the first of which is now being constructed near the village of Kembs.

History of the Project—The middle section of the Rhine River from Lake Constance to the mouth of Main presents many obstacles to navigation on account of seasonal variation in flow, meanderings, shifting banks and even rapids. By cutting through the necks and stabilizing the channel, the head of navigation was advanced, in the past, first to Mannheim and them to Strassburg. Further upstream navigation can be carried on for about half the year. Shipping avoids the river by using the Rhine-Rhone canal and a branch canal by way of Mulhouse to Huningue, 1 mile from Basle. These canals, however, have become inadequate in spite of the electric traction installed since the war. Further, as there is a fall of 108 m. between Basle and Strassburg, the river offers attractive possibilities for power development. About 900,000 hp. can be developed.

The Rhine River, in the section under consideration, leaves Switzerland to form first the boundary between France and Switzerland and then between France and Germany. The Swiss people, having plenty of power of their own, favored developing the river primarily for navigation, but the people of Alsace, an industrial region, favored the development of power in addition to improving navigation. The matter was settled by the treaty of Versailles, which gave to France the right to construct the Grand Canal d'Alsace and the power plants, also to divert water from the river for the development of power for its own use, paying Germany a royalty

Fig. 2—The Kembs Canal and power project is located on the Rhine River just below the point where the river comes out of Switzerland and forms the boundary between France and Germany.



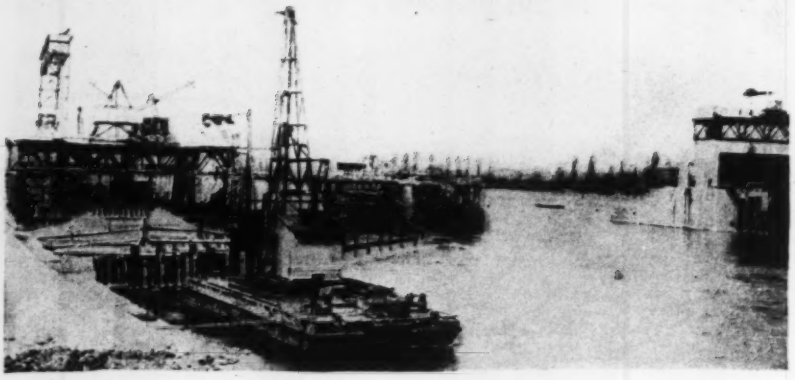


Fig. 3—Construction of the dam to control the flow of the Rhine River was carried out from the two banks, leaving the central section open for river flow and for navigation.

for water diverted from the German half of the river. Germany consented to the construction of necessary dams and other works on the German side of the river, and France agreed always to maintain the canal open to all nations, tax and duty-free.

Construction of the first section of the development scheme was begun in the spring of 1928 and is expected to be finished this year.

Kembs Project—The Kembs project consists of a dam across the Rhine River about 5½ km. downstream from the Franco-Swiss boundary, a lateral canal about 6 km. long leaving the river one-half mile above the dam, and a power house and lock near the lower end of the canal where it returns to the river. The canal is shown in the accompanying map.

The dam is of a type commonly called a barrage in Europe. Except for the abutments it consists of a sill extending entirely across the river surmounted by piers supporting five stoney gates 30 m. (98 ft.) wide. There will be a depth of water above the lowest sill of 11.5 meters, which will set the water level back into Switzerland to a point just above the city of Basle. This will require complete revision of the sewage and drainage system of the city, to be paid for by the French government.

As the main channel of the river had to be kept open for navigation during the period in which the canal and locks were under construction, the two ends of the dam were constructed as separate operations, working out from each shore, leaving one section near the center of the river open. When the canal is ready to be put into service for shallow-draft vessels, the central section will be closed off and completed. Foundations for the sill and piers on the French side of the river were sunk by the pneumatic process, and on the German side in open cofferdams of steel sheetpiles.

Navigation and Power Canal—For the greater part of its length the lateral canal serves for both power and navigation. Where so used it has a bottom width of 80 m. (260 ft.), top width of 150 m. (500 ft.) and a maximum depth of 12 m. (39 ft.).

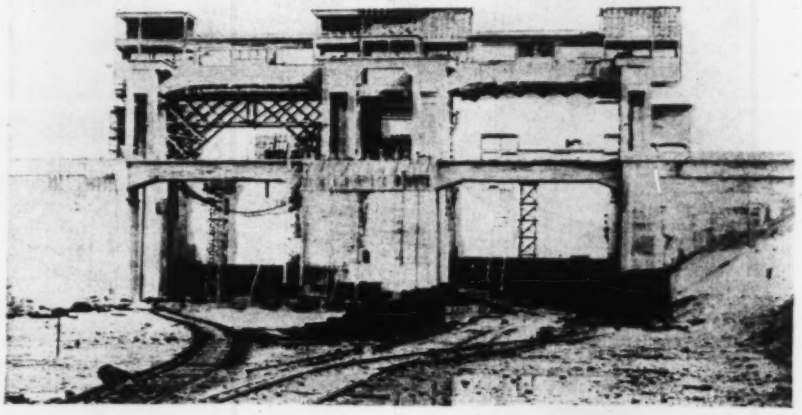
Gravel excavated from the canal was used, in large part, for the construction of embankments forming the sides of the canal for the greater part of its length. At the power house the elevation of water in the canal will be about 9 m. above the level of the surrounding territory. Drainage from land back of the embankment is provided for by a parallel drainage channel leading to the river below the power house.

On account of the great size of the canal and the large amount of material to be moved from the canal prism into the embankment, very large excavating equipment was provided for its construction. Dredges and dragline excavators (the latter of American make) were used for the preliminary excavation, and the finished bank was built by very large bucket excavators. In a little more than two years nearly 12,000,000 cu.yd. of material was taken out of the canal and disposed of. Only a little over 1 per cent of the total amount was rock requiring blasting.

The canal is lined with concrete on the side slope throughout the greater part of its length and is lined on both

Fig. 4—Concrete was placed on the slope by a traveling machine that spread the concrete, placed the reinforcing mesh and tamped and finished the surface in one continuous operation.

Fig. 5—Parallel locks of different lengths and depths serve the new navigable channel. The channel is designed for barges requiring only limited headroom.



the slopes and bottom in the headrace and tailrace sections. Generally, the lining is 6 in. thick, except in the tailrace, where it is much thicker, ranging from 36 in. at the power house to 12 in. near the mouth.

Placing of the concrete, so far as possible, was done mechanically, a special machine being used that placed the concrete on the slopes, embedded the reinforcing mesh, tamped the concrete and finished the surface. Hand work was employed only on curved surfaces and in limited sections where the machine could not be used.

Locks—Two locks, independent of each other, are being built for the navigation canal. Both are 25 m. wide; one has a service length of 185 m. and the other 100 m. The average lift will be about 40 ft.

Placing of concrete in the lock wall was accomplished by the use of an elaborate system of movable towers and chutes supplied with concrete from mixers mounted on the main towers.

Power Plant—The power plant has been built with space for six vertical-runner turbines of 33,000 hp. each, operating under a net head ranging from 12.6 to 16.5 m. (39 to 54 ft.). Five turbines are to be installed at the present time.

An unusual feature of the plant is a series of sluiceways extending from the upper level of the intake down through the power house, passing to each side of the turbine shafts, to the tailrace, where they discharge above the level of the mouths of the draft tubes. These sluiceways are to be used to equalize the flow in case one or more units are shut down, also for the discharge of floating debris and ice from the headrace.

License owners for the undertaking are René Koechlin, consulting hydraulic engineer, Basle, and the Société des Forces Motrices du Haut-Rhin. Together these firms organized the Société Energie Electrique du Rhin ("Enerin"), with a capital of 250 million French francs, for the construction of the power plant, locks and canal. The French government gave "Enerin" the power to secure the necessary lands by expropriation. The dam is owned by the French government, which, acting on behalf of the "reparation-account," commissioned the German firms Dyckerhoff & Widmann and Siemens Bau-Union as builders; the firm of Locher & Co., in Zurich, Switzerland, acted as consulting engineers. The builders of the power house were given the job of supervising the construction of the diversion structure. For the construction of the other parts of the project, "Enerin," together with the following four firms, Société des Grands Travaux de Marseille, Maison Fougerolle Frères, Société Générale d'Entreprises and Compagnie d'Entreprises Hydrauliques et de Travaux Publics, acted jointly.

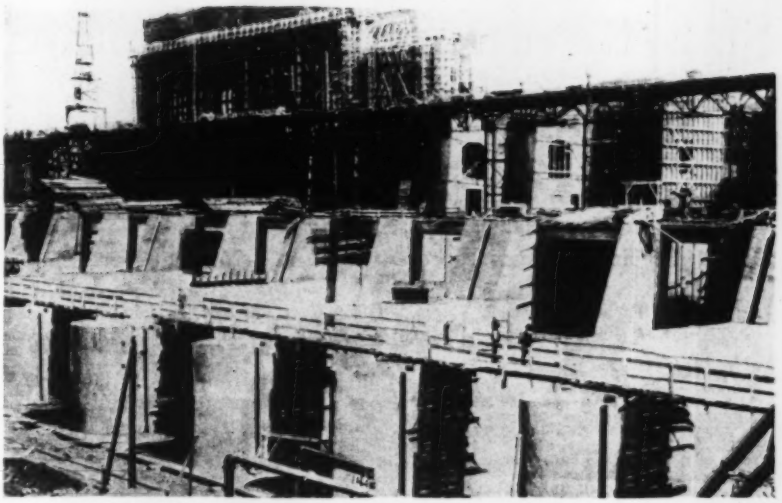


Fig. 6—Sluiceways to bypass the power house when the turbines are shut down are included in the substructure of this power plant. They discharge into the tailrace through openings below the bridge upon which the concrete mixer stands in this view of the downstream side of the power house.

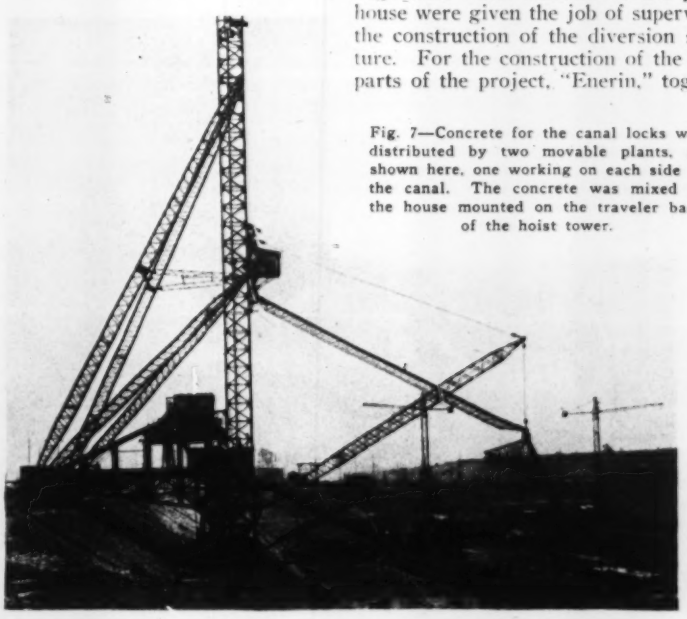


Fig. 7—Concrete for the canal locks was distributed by two movable plants, as shown here, one working on each side of the canal. The concrete was mixed in the house mounted on the traveler back of the hoist tower.

As noted previously, the cost of reconstructing the drainage system of Basle is to be borne by "Enerin." In addition, 20 per cent of the power is to be turned over to the city as compensation for the theoretical power available in the river within the Swiss border.

The information upon which this article is based was supplied to *Engineering News-Record* by P. E. Baumann, Zurich, and Carl Hanns Pollog, Weil, Germany.

Germans Plan 16,000 Houses for Unemployed

The German federal commissioner for suburban settlements has announced plans for the construction of 16,000 wooden houses, costing $11,425,000, for the unemployed in the suburbs of German industrial cities, states a report from vice-consul O. W. Gray at Berlin that was recently made public by the lumber division of the Department of Commerce. The German authorities calculate that a small wooden house can be constructed for $429, the rest of the cost being for furniture and equipment. The settler is required to give his own work in the construction of his house. The number of houses to be built will be increased, it is reported, providing that tenants are found who have funds to assist in the financing. Construction will probably begin as soon as suitable spring weather allows.

The houses will consist of a living room of 12 to 14 square meters; a bedroom of 9 to 12 square meters; two small bedrooms; a small stable of 5 to 6 square meters and a cellar of at least 4 square meters. In addition, sheds will be provided for the storage of tools and other essential articles.

Slab-Revetment Equipment, Mississippi River

Special machines for bank grading and elaborate plant for casting concrete slabs and assembling them on steel cables into flexible mats represent a huge investment

By Brehon Somervell
Major Corps of Engineers; District Engineer, Memphis, Tenn.

Slackline cableway with one floating and one land tower adapted for bank sloping with bottomless drag bucket.

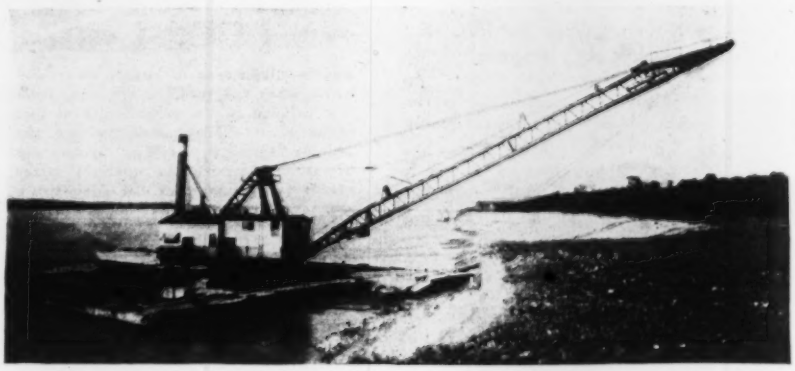
A PLANT costing upward of a million dollars is required for a concrete bank-revetment operation on the Mississippi River. The major part of this investment is for the large fleet of towboats and barges on which equipment is mounted and which are required for transportation, but mixing-plant equipment, hoisting machinery, cranes, excavating equipment and miscellaneous machinery are large items, too. Also some of the barges, as the mat-launching barges, are virtually special equipment. Concrete bank revetment is therefore largely a problem of equipment planning and operation, although construction management offers many problems of judgment and determination of procedure. It is as a presentation of equipment that the following article has been planned, with enough discussion of methods to make the equipment requirements understandable. Incidentally the type of revetment described is less well known than the type consisting of flexible mats of small blocks used on the two lower engineering districts of the Mississippi. The large-slab revetment is characteristic of the Memphis engineering district. —EDITOR.

AMONG the types of bank protection that have been developed for use on the lower Mississippi River is one using a mattress composed of large precast concrete slabs. These slabs are used for all of the subaqueous work and to some extent for the work lying in the border zone just above the water's edge at the low stage at which this work is always done. The upper bank protection, except for the ends of the work where a certain amount of flexibility is desired, is monolithic concrete paving. Prior to the installation of any of the revetment, the riverbed is first cleared of snags and other obstructions and the bank is carefully graded to a 1 on 3 slope.

Bank-grading equipment

The equipment that has been developed for the grading operations is interesting. In the early days of bank protection no attempt was made to grade the banks, reliance being placed entirely on the flexibility of the mattress to cover any irregularities encountered. This was soon found to be unsatisfactory, and hydraulic grading was introduced and developed to a high degree of efficiency. By this method it was possible to grade only to the water's edge. Not only was this a handicap, as grading of the bank to the lowest possible point was found to be a factor of prime importance in the stability of the revetment, but also, unless there was a swift current to carry away the graded material, a shelf was left at the water's edge. The gullies which were sometimes formed in easily eroded material were also objectionable.

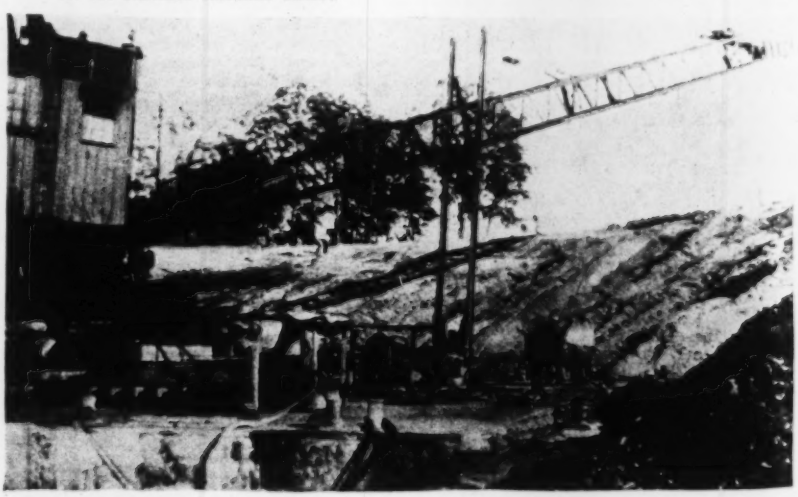
Efforts were made, therefore, toward the development of some satisfactory form of mechanical grading. A number of types of grading machines were available as examples, as the gigantic task of building levees along the river had permitted the development of some highly efficient earthmoving machines. The simplest of the types which have found application in grading banks for revetment is the dragline. This is a very satisfactory machine for the purpose, and has handled the maximum yardage moved in any one day on this type of work.



Dragline excavator mounted on a barge and operating a bottomless drag bucket is one of the most useful devices for sloping bank for revetment.

An adaptation or modification of the dragline which has been very useful is a machine that carries on its boom a stiff-handle drag on which a hoe is suspended. The hoe may be raised or lowered as required, and when drawn toward the machine drags the material with it. Highly accurate results can be secured with this type of machine, as the boom can be set exactly on the slope desired and the hoe can be set within a fraction of an inch, a degree of refine-

A variant of the dragline for bank sloping substitutes a rigid-handle pull dipper for the standard slackline bucket.



Sloped bank ready for paving up-bank from top of revetment of lapped slabs now virtually abandoned for butt slabs.

ment far beyond what is necessary in practice.

Another machine that is proving highly satisfactory is an adaptation of the tower excavator used in levee construction. This is a slackline-cableway excavator. The tail tower used along the top of the bank is similar to the tail tower used in levee construction and the main tower is a converted dipper dredge. The tail tower must possess considerably more flexibility than the tail towers used in levee building on account of the irregularities in the bank. The work of the main machine is no more difficult than that of the levee tower machine except that the under-water grading requires somewhat better judgment on the part of the operator.

The illustrations show the different types of machines and the method of breasting them off from the bank. It has been possible with these machines to secure the requisite slope extending a few feet below the water surface and an evenly graded upper bank which requires very little dressing before placing the concrete.

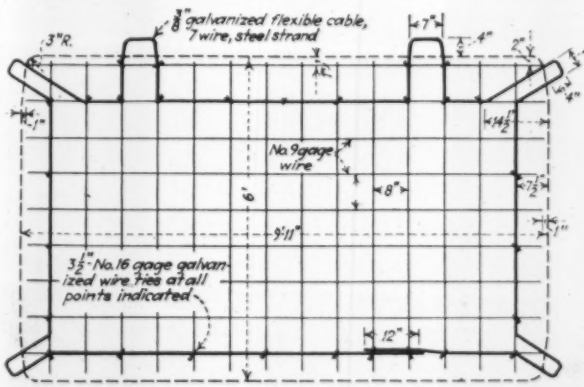
The principal difficulty in grading comes from the rise and fall of the river which may occur during the operation. The variation in stage is accompanied by action from current and waves, which tends to cut a shelf in the bank. In order to eliminate this form from the final work various methods have been adopted. One of the two principal methods is to make the original cut on a lesser slope than the final slope desired, and the other is to make the cut on the slope desired by leaving a shelf just above the water's edge. With either of these methods it is possible to go back over the work with a small machine and re-dress the portions cut by the current and waves without having to regrade the entire slope.

Floating mixing plant casting slabs in tiers on barge; old style lap slabs being cast in the operation shown here.

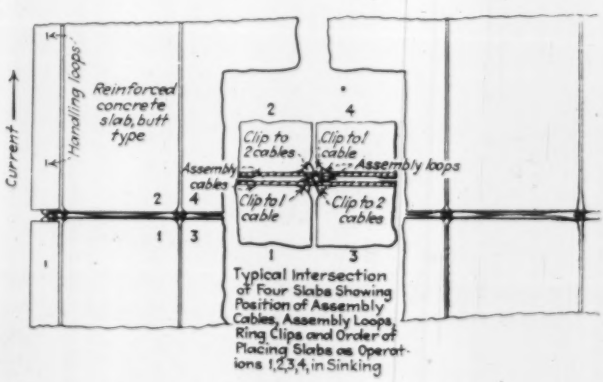
Slab design

After the bank has been dressed the mattress is placed in position. The designers of this mattress sought a form which would be composed of units heavy enough to maintain their position on the bottom without the assistance of fastenings and at the same time be flexible enough to adjust themselves to any irregularities left under water in the grading process or which might develop through erosion. This led to the adoption of a slab 4 in. thick, 6 ft. wide

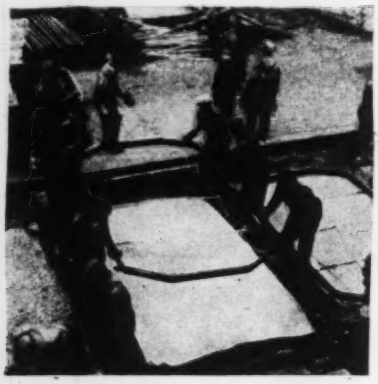
Wire-fabric and steel-cable reinforcement for latest design of butt-slab revetment.



Arrangement of butt slabs in mattress showing arrangement of ties at intersection of four slabs.


Current
Handling loops
Reinforced concrete slab, butt type
Clip to 2 cables
Clip to 1 cable
Assembly cables
Assembly loops
Clip to 1 cable
Clip to 2 cables
Typical Intersection of Four Slabs Showing Position of Assembly Cables, Assembly Loops, Ring Clips and Order of Placing Slabs as Operations 1, 2, 3, 4, in Sinking

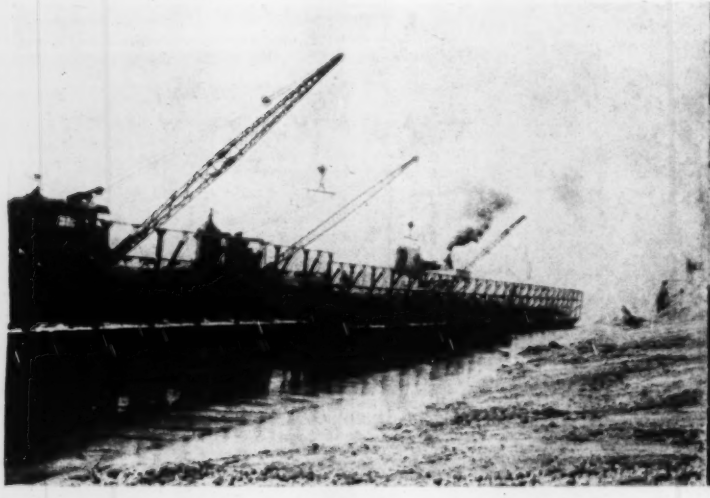
Placing paper to separate one slab from a slab to be cast on top.

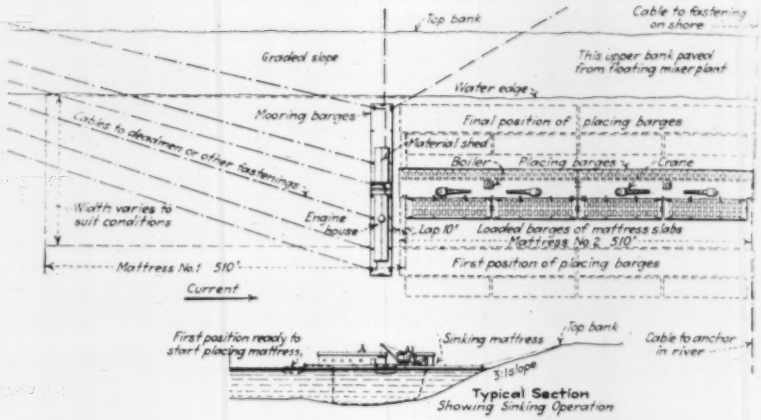


Steel forms holding the reinforcement for a second slab are set on the paper covering the slab below.

and 11 ft. long. The slabs were laid like the shingles on a roof. In order to permit this operation under water the corners of the slabs were beveled so as to permit nesting. Guide cables were run both under and over the slabs from anchor blocks placed at the outstream edge of the work. The slabs were slipped into position on these guide cables in much the same manner as a circus performer making the "slide for life" down a wire.

Front of slab-laying barge, showing slabs being woven onto cables to form revetment when lowered to river bottom.





Schematic arrangement of slab revetment operation.

Due to the fact that approximately 1 ft. was used in overlap on this type of revetment and that an equally satisfactory articulated type had been developed which did not use so much material in overlap, it was decided to use a butt-slab type of construction rather than a lap-slab type. To this end the slabs were redesigned with dimensions of 6x10 ft. by 4 in.

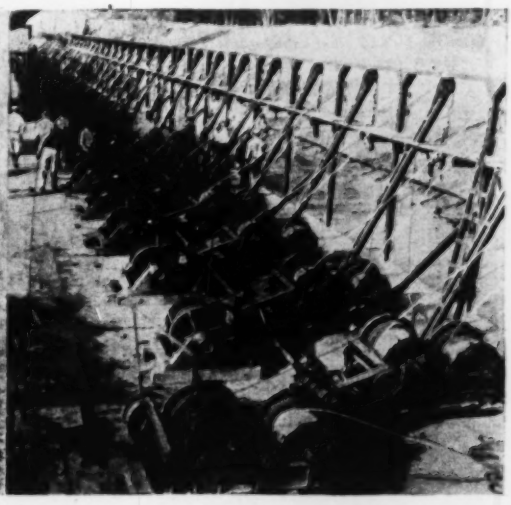
The method of reinforcing the slab is shown in an accompanying illustration. The mesh is composed of No. 9 gage wire, around the edge of which is fastened by means of No. 16 gage tie wires a continuous $\frac{3}{8}$-in. flexible seven-wire steel cable. In addition to reinforcing the edges of the slab the principal function of this cable is to form the assembly loops at the four corners and the two handling loops projecting from one edge of the slab. Assembling of the mesh and the border cable is done on the job, as it was found that it could be done there more economically than the unit could be bought ready made.

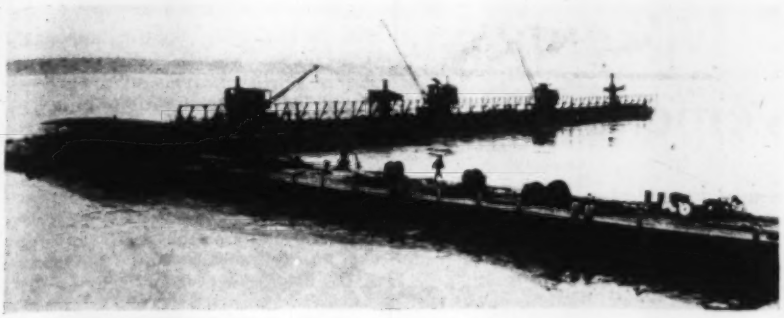
Sinking equipment

The plant used in the sinking operation is large and expensive. The arrangement, types of barges and machinery are shown in accompanying illustrations. The mooring barges are first set perpendicular to the bank and held in place by means of cables run to the shore. The sinking barges, about 500 ft. long, are then placed in position near the outer edge of the mooring barges and perpendicular to them. The header blocks are sunk on a line previously determined for the outside edge of the mattress and then the slabs are placed, working toward the bank.

Two locomotive cranes on each of the sinking barges remove the slabs from the material barges and place them on racks. While the slabs are suspended on these racks clips are placed fastening them to the guide cables. The mechanism is then tripped and the slabs are allowed to slide one by one down the cables to their final position. The sinking barges, when one row of slabs has been placed, are moved shoreward 6 ft. and a second row of slabs is laid. When sinking operations have thus proceeded to the water's edge the cables are run up the bank and slabs are placed with a derrick boat to a sufficient height to prevent damage to the graded bank from wave wash or current. These cables are

Deck of slab-laying barge, showing train of machinery for stringing slabs on cables and sinking mattress.





Sinking plant ready to begin the laying of under-water slab revetment mat.

later embedded in the upper bank paving.

As satisfactory results had been obtained with the articulated mattresses, which were only 3 in. thick, it was decided to investigate to ascertain whether equally good results could be obtained with slabs of the same thickness. Preliminary investigation indicated that the thinner slabs could be handled satisfactorily, and as a result the most recent slabs to be placed are only 3 in. thick.

Some idea of the complicated machinery required in these operations can be obtained from the pictures.

Casting equipment

The slabs are fabricated with floating equipment. The mixing barge has two 1-yd. mixers mounted on it, with separate hoppers for the aggregates and inundators to permit accurate proportioning of the mix. For each mixer there is a bottom-dump bucket traveling on a horizontal boom to distribute the batch in the forms. The forms are placed on two material barges, which are moved under positive control back and forth in front of the mixers as the concrete is being poured. The slabs are poured in piles with manila paper between each two slabs to prevent bond, and the forms are removed when the concrete has set enough to support the weight of the slabs above. About 400 slabs are cast on each barge. Uniform strengths of 2,000 lb. are obtained, before sinking, from five to seven days after the slabs are cast.

The cement in bags is delivered to the site on barges and handled into the mixers over belt conveyors. The sand and gravel are dredged from near-by bars in the river, delivered in barges, and placed in the hoppers over the mixers with clamshell buckets. The fabric and border wires are assembled on other barges at the site and as fast as the forms are removed and cleaned the fabric is set and the assembled unit placed for casting. Accompanying illustrations show the plant used, the type of forms and the type of reinforcement.

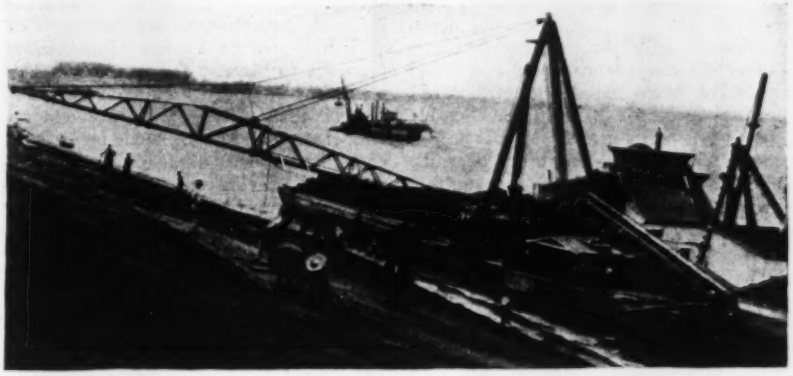
To accomplish the necessary progress during the short construction season it has been necessary to develop plant capable of a very high rate of production. By means of careful planning, organization and management it has been possible to cast 4,200 slabs in one day and to sink 5,100.

The cost by reason of the elimination of the lap and reduction of the slab to 3 in. in thickness has been brought down below that of any other type of effective revetment yet devised.

Bank-paving equipment

After the bank has been graded and the mattress fabricated and sunk as described, the upper bank paving is placed. This paving is a monolithic concrete slab 4 in. thick, without reinforcement, and is installed by means of a floating concrete mixer. The mixer, equipped with ultra-modern equipment accurately to gage the character and strength of the mix, is also furnished with a boom which in ordinary circumstances will reach the top of the bank. The batch is dumped from the mixer into a bucket which is run up the boom and dumped on the graded bank at the point desired. This method has been found to be superior to chuting. A dense uniform concrete paving is secured. As a rule the pavement is laid in strips about 20 ft. in width. Construction joints are made whenever it is necessary to suspend operation, and expansion joints are provided at intervals of about 200 ft. Where seep water is encountered, suitable provisions are made for drainage. For a short distance at each unprotected end of the pavement where flexibility is desired the pavement is constructed with slabs placed by a derrick. Accompanying illustrations show the character of the finished work.

Floating concreting plant lays solid slab paving from upper edge of flexible slab revetment to top of bank.



Standardizing Manhole Frames and Covers

Several years ago a committee was authorized by the American Standards Association to investigate the possibility of substituting a standard series of manhole frames and covers for the thousands of types and sizes now in common use. Advantages of such standardization would include greater speed and economy in manufacture, easier inspection and more rational design. The committee in its investigation has attacked the problem from three angles—size, shape and material—and has prepared proposed specifications and drawings covering thirteen types of frames and six types of covers in seven different sizes. These specifications will be distributed for criticism to municipal authorities, public utility companies, foundries and others interested in the manufacture and use of manhole covers.

Recommendation of a committee may be summarized as follows: Clear diameter of frame should be limited to seven sizes—22, 24, 27, 30, 33, 36 and 42 in. In regard to material, frames and covers for sizes up to and including 30 in. in diameter should be of gray cast iron; larger sizes require the use of cast steel in order to reduce the weight of the cover to a point where it can be handled conveniently. In all cases the shape of the cover should be circular, as this design requires less metal per unit area of opening than any other shape, and the machining of the cover is simplified. Frames, however, can be flared out to connect with square or oblong openings. Machining is specified for both the horizontal and the vertical faces of the cover seat in the frame and for the surfaces of the cover that come in contact with the seat. This has been done in order to obtain an even bearing, thus preventing rocking and reducing wear and noise.

L. B. Fish, of the American Telephone and Telegraph Co., New York City, is chairman of the committee.

Filling Cuts and Openings in Concrete Pavement

Careful preparation of the subgrade and knowledge of how to cut the pavement are essential to success—Concrete must be mixed stiff and tamped thoroughly to assure a proper bond

RESTORATION of concrete pavement where utility openings have been made or surface failures have occurred is one of the most exacting tasks. Unless the replacement is perfect it becomes a weak spot that impact searches out and breaks down, and always it is a patch and imperfection to the eyes of the road user. This last aspect possesses enough seriousness to have led to definite attempts to color the new concrete to match the color of the adjoining old pavement. But the real problem of replacement is to keep the original slab smoothness, to insure the edge bond of the new and old slab and to make the new slab as strong as the adjoining pavement. Methods that will attain these objectives are outlined in the following abstract of a paper by F. D. Woodruff, assistant superintendent of maintenance, New Jersey highway commission, Trenton, N. J., read at the recent meeting of the Association of Highway Officials of the North Atlantic States. —EDITOR.

THE RESTORATION of a utility opening or a slab replacement due to local surface failure does not permit of the long-period curing possible in original construction. The curing time, when proper control is exercised, can be reduced to 18 or 24 hours, and even, under strikingly adverse conditions, to a maximum of 72 hours. Where patches are to be opened to traffic in eighteen hours the conditions must be almost ideal, workmanship must be of the best, and accelerating admixtures generally must be employed.

Materials

The use of special cements is not recommended. Special cements undoubtedly have merit where conditions warrant the expense and technical control, but unusual curing methods and treatment are not readily adaptable to average working conditions. Finely ground and specially burned portland cements, requiring no treatment other than that given ordinary cement, may be used. These cements are not always obtainable upon short notice, and it follows that the standard commercial brands are the portland cements that will generally be available for emergency repair.

The water, sand and coarse aggregate should have the qualities generally required for high-class concrete work.

For general work the proportions should be between 1:1½:2 and 1:1¾:3½, the richer mix being used for patches averaging 2 sq.yd. or less, for which a ¾-in. aggregate is preferable, and the leaner mix for patches exceeding 3 sq. yd., where a coarser aggregate can be used. The smaller the repair area the greater is the effect of impact on bond; therefore small areas should have closer attention, and richer and denser mixtures should be used. Whatever mixture may be determined upon, it is essential to increase slightly the cement ratio. This increase may be fixed at 10 per cent, although during summer temperatures where admixtures are used, flash set should be closely guarded against.

Subgrade preparation

Not less than 6 in. of pavement should be removed beyond the edge of the utility trench (Fig. 1). The subgrade so exposed, if of the proper stability, should not be adjusted in any manner. No foreign materials should be added except where it becomes necessary to remove unstable material for a depth in excess of 6 in. Where the removal of the subgrade for a depth exceeding 6 in. becomes necessary, a thoroughly compacted sub-base of broken stone or other suitable material should be substituted (Fig. 2). To overcome the possibility of such instability extending beyond the limits of the repair section, the subgrade under and adjacent to the section to be patched should be removed as far as possible. While this treatment may not be as effective as the removal of additional pavement, it has been found that by this treatment the radiating of progressive failures has been almost completely overcome.

Preparation of edges

No edges, uniformly plumbed and tooled for the total depth of the pavement, should be permitted. The cut, however, should be plumbed not to exceed 1 in. to get a firm shoulder. An edge smoothly plumbed the total depth is required only where expansion and contraction are to be considered. Old cuts have been found into which oil film has penetrated to a considerable depth. No permanent bond can be expected where this condition prevails. Where a permanent bond is required, a perfectly plumbed edge only invites early failure of the union between the old and new pavement and the consequent "punching out" of the restoration. A rough uneven adjacent edge, properly treated, adds materially to the strength of the repair section and insures more effective bonding.

Spalled or scaled areas of old concrete immediately abutting upon the area to be restored should not be plastered with portions of the mixture placed in the restoration (Fig. 2). Such shallow repairs quickly chip out and thus leave a non-uniform surface, subjecting the restored area to undesirable impact loads. To obviate this condition, it may be necessary to remove sufficient additional old concrete to provide an even surface at the intersection of the old and new concrete.

Reinforcement

Reinforcing steel, preferably ⅜ in., should be placed 2 in. above the bottom of the slab. The amount to be used will depend upon the dimensions of the opening that is being repaired and upon

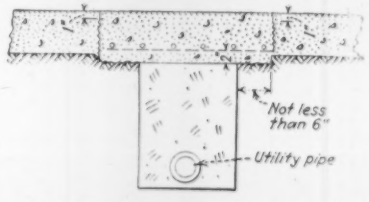


Fig. 1—Normal design for pavement replacement over opening for a utility trench.

Fig. 2—Pavement replacement in unstable subgrade requiring stone sub-base.

the condition of the subgrade. In general, the spacing of this reinforcement should conform to the spacing found in the old pavement both transversely and longitudinally. Where pavements are reinforced, the existing reinforcement in the area of the repair should be tied in with new reinforcement. Where pavements are unreinforced, a mat of bars not more than 12 in. c. to c. should be employed. In case of extra-deep patches, two lines of reinforcement may be used (Fig. 2).

Placing concrete mixture

The edges of the existing pavement should be thoroughly washed, wire-brushed, wetted down and painted with a 1-to-1 mortar coating immediately previous to placing the concrete. This treatment is quite essential at all times, but obviously more so with high summer temperatures. During such periods the edges must be completely cooled and saturated previous to the mortar coating, which must be followed immediately by the concrete fill.

The water content of any plain mixture should not exceed 4 gal. per bag of cement. This water factor is further restricted by the moisture content of both fine and coarse aggregates. The concrete, without admixture, should be

mixed not less than 2½ to 5 min. in a machine mixer. No hand mixing should be employed. The resultant mixture should flow from a square pointed shovel with difficulty and should show no appreciable slump when dumped upon the subgrade. Any mixture showing more than a 1-in. slump in 12 in. should not be used in high-early-strength repair work. The 4-gal. water-cement-ratio mixture will, as a rule, produce a consistency that is called unworkable. This unworkable mixture should be placed in the repair area in 2-in. layers, each layer being thoroughly compacted. The repair in layers should be complete before initial set takes place. The final layer must be tamped sufficiently to bring out a workable surface; the surface should be roughly planed and kept slightly above the finished grade. The final tamping and finishing of the surface should be done as late as possible in order that, practically speaking, the shrinkage of the concrete may be worked out prior to the time of setting up. The proper time for performing this final operation will vary under different materials, but it is best recognized by the dried-up-surface appearance of the concrete. At this point the concrete should be tamped thoroughly, planed to grade and finished to proper surface. Unless the surface of the patch is retamped and finished at this later period, all bond may be lost. No proper bond can be expected unless the concrete mixture is reworked at the time final shrinkage is about to take place; neither can a suitable bond be expected unless the edges of the adjacent concrete are first cleaned, washed and given mortar treatment.

Use of admixtures

A portland cement concrete mixture containing calcium chloride should contain no more water than that used in plain mixtures, but such mixtures must be manipulated much more quickly in relatively high temperatures than the plain-cement combinations. Initial set takes place much earlier in high temperatures, and in consequence the depth of the layers to be tamped should be increased to not less than 4 in. The same procedure of finishing as used for plain-concrete mixtures should be followed just prior to the initial set, although at low temperatures there appears to be no difference between the action of a calcium-chloride-treated mixture and an untreated mixture in summer weather. The water and fine and coarse aggregates should be heated during freezing temperatures. This will insure more rapid hardening of the concrete. Where this procedure is followed, temperature conditions must be given utmost consideration, and the proportions of admixture, if used, must be carefully controlled. The mechanical mixing time should not exceed 2½ min. in summer temperatures. Where the mixing time is in excess of this period, the mixture may set up in the drum of the mixer, or before the final tamping of the repair section has been completed.

For rapid acceleration at temperatures above 70 deg., a 1½ per cent calcium-chloride solution may be used. At temperatures between 50 and 70 deg., a 2 per cent solution: 32 to 50 deg., a 2½ per cent solution; and at temperatures from 24 to 32 deg., a solution containing 3 per cent calcium chloride has been found satisfactory. No two portland cements will, however, react the same in combination with such an admixture, but for average working conditions these rules can be followed.

Snow Records in California Indicate a Good Water Year

Survey of snow depth and water content show that much more water is held back in this form of storage than in former years

SURVEYS made in the latter part of February at key snow courses and the available precipitation data to March 1 for mountain stations of the U. S. Weather Bureau and the several districts and public utilities of California, indicate depth and water content of the snow to March 1 from two to four times greater than the depth and water content of a year ago. In many instances, however, there is a wide variation between the courses of the various stream basins in the amount by which the depth and water content of last year is exceeded. This fact renders any generalization quite difficult, as is illustrated in the following comparison between this and last season's snow by stream basins:

Stream Basin	Number of Courses for Which Data Are Available	Number of Times by Which Water Content of Snow to Date Exceeds the Corresponding Water Content of Last Year	
		Average	Range
Upper Sacramento, Pit and McCloud	2	1.5	1.4 to 1.7
Feather	4	6.8*	1.7 to 10.8*
Yuba	5	3.3	2.2 to 6.7
American	4	2.7	2.2 to 3.2
Mokelumne	2	3.6	2.9 to 4.4
Stanislaus	4	4.4	3.8 to 5.8
Tuolumne	6	3.6	2.6 to 5.8
Merced	6	2.9	2.6 to 3.4
Upper San Joaquin	3	3.8	3.3 to 4.2
Kings	1	5.6	
Kaweah	3	3.0	2.7 to 3.3
Kern	1	2.4	
Truckee	1	2.2	
Carson	2	3.0	2.9 to 3.2
Mono	2	4.3	3.1 to 5.5
Owens			
Upper	4	4.1	3.8 to 4.6
Rock Creek	3	7.0	6.0 to 8.4
Bishop Creek	2	5.0	4.7 to 5.3
Big Pine Creek	3	10.5	9.1 to 12.8
Cottonwood Creek	2	5.0	4.3 to 5.6

*Greatest depths for any courses in the state reported for Bucks Lake vicinity.
Distribution of the four courses is too limited to be representative of entire Feather River basin.

For a few courses only the period of record of the surveys has been sufficient to permit of the development of normals. Of these, three in the Yuba basin indicate an average water content of the snow to date amounting to 116 per cent of the normal for the entire season (up to April 1), and Blue Lakes on the Mokelumne-Carson divide, Rhinedollar Lake, close to the Tuolumne-Mono divide and Mammoth Pass on the San Joaquin-Owens divide show respective water contents of 113, 123, and 124 per cent of the entire seasonal normal.

The amount of snow reported on the ground at Donner Summit on March 1 was 110 in. This was 12 per cent above a 33-year average for this date of 98 in. In ten of the years in the period from 1898 to date the depth on March 1 has exceeded 110 in., and a maximum depth for March 1 of 215 in. was recorded in 1911.

The data from the precipitation stations show, in general, a progressive increase in the percentages of normal to March 1 in going from the northern to the southern stream basins. Thus, the average precipitation up to March 1 was from 10 to 15 per cent below normal in the Upper Sacramento, Pit, McCloud and Feather River basins; from 5 to 10 per cent above normal in the basins from Yuba to Stanislaus; about 30 per cent above normal in the Tuolumne and Merced Basins; from 45 to 50 per cent or better above normal from Upper San Joaquin to Kern Basin; and from 60 to 90 per cent, with a general average of about 75 per cent above normal, in the Los Angeles, San Gabriel and Santa Ana basins. A comparison with the corresponding percentages on Feb. 1 shows that during the month the precipitation in the northern basins fell from above to below normal; maintained about the same percentage above normal or fell slightly in the central basins; and considerably increased the percentage above normal in the basins of the south. As an average for the eastern basins, the data indicate precipitation to March 1 varying from 20 per cent above normal in the Tahoe-Truckee and Mono basins to a maximum of 100 per cent above normal in the Owens basin.

These data are presented in the monthly bulletin of the snow survey and precipitation data compiled by the California division of water resources.

Letters to the Editor

Successful Private Toll Bridges

Sir—You might add to your list of successful private toll bridges the Hood River-White Salmon bridge over the Columbia River. It has just completed seven years of operation, during which time it has reduced its first-mortgage indebtedness 35 per cent.

Olympia, Wash., March 16, 1932. ELBERT M. CHANDLER.

License Law Accomplishments

Sir—Mr. Steinman's catalogue of virtues inherent in license laws from the standpoint of the practicing engineer (*ENR*, Feb. 25, 1932, p. 297), coupled with the realization that such laws are enacted as safety measures to protect the lay public against incompetency and malpractice, forms an impressive exhibit. Of necessity, many years must elapse before statistical evidence of the beneficial effects of such legislation will be available, or evidence that the awful annual toll of injured and dead attributable to incompetent and dishonest engineering has been materially reduced, or that the sorry financial plight of the professional engineer has been alleviated and the status of the profession elevated more nearly to that of other professions.

Obviously, restrictive legislation as applied to occupations is important from the public standpoint only in so far as it applies to persons undertaking to assume direct responsibility to the public for the results of services rendered or work performed. Thus, engineer assistants employed by registered engineers need not themselves be registered. Hence, to those of us who had long looked upon New York City as the center of super-engineering activity, it comes as somewhat of a shock to be informed that of the 35,000 professional engineers registered under laws of 28 states, California holds 6,000 to New York State's 10,000.

The California law applies only to persons "practicing or offering to practice *civil engineering*." Since there are less than 1,400 corporate members of the American Society of Civil Engineers resident in California, more than half of whom are associate members and fully half of whom have no such direct relations with the public as would necessitate registration under the law, evidently either the appellation of civil engineer is considered to have unusual intrinsic value in California beyond anticipation, or the registration board has been actuated by megalomania, or perhaps both.

Regarding the fifth "fact" in Mr. Steinman's summary, which states: "The courts have ruled that a contract for engineering services is invalid if the party undertaking to furnish such services is not registered." In a recent California case the validity of an award of contract by the city of San Diego to a non-registered person to make engineering plans for a sewer system was challenged by the registration board, but all legal requirements were satisfied, substantially, by changing the word "make" to "procure" and by re-awarding the contract to the same person. This was widely acclaimed by the board as "victory No. 1" under the law.

San Francisco, Calif., March 3, 1932. E. T. THURSTON, Consulting Engineer.

Chilean Irrigation Works

Sir—Referring to the article entitled "Earthquake-Proof Dams in Chile," which appeared in *Engineering News-Record* Nov. 5, 1931, p. 725, the former director of the department of irrigation, Alberto Decombe, has requested the Instituto de Ingenieros de Chile to explain certain facts in connection with the design and construction of the works in question. The board of directors of the Instituto de Ingenieros de Chile, which I represent, has considered the request of Mr. Decombe, and I wish to advise you of the facts developed, in order that the Chilean engineers engaged upon the work may receive the credit due to them.

The Chilean government had determined in 1929 to carry out a vast plan of public-works development, including the construction of numerous dams and canals for the purpose of national irrigation. The Bureau of Public Works was entrusted with the studies, plans, supervision and execution of all the works included in this plan, the estimated cost of which amounted to 1,175,000,000 Chilean pesos, or about $142,944,000 in money of the United States of America.

The engineers of the Bureau of Public Works had already started the studies and also the construction of these works when the Bureau, desiring to avail itself of the knowledge and experience gained in dam design and construction in the United States of America, decided to engage the services of the distinguished American engineer James B. Girand to serve as consultant in the design and execution of these works.

Mr. Girand came to this country as consulting engineer, and we are glad to acknowledge that on various occasions the Bureau of Public Works took into consideration his advice. The Bureau, however, as the technical office of the government, was entrusted with the studies, execution and supervision of all public works in the country, including the dams under discussion, and was responsible for the work to the government of the republic.

In consequence the work of preparation of plans, supervision and construction was the duty of the Bureau of Public Works, and its personnel directly carried out the work in question. The Instituto de Ingenieros de Chile appreciates fully the value of the cooperation of Mr. Girand, but considers that the group of Chilean engineers who have studied and directed this work should receive the credit for the projects that form their professional inheritance.

I have the pleasure of giving herewith a list of the dams together with the names of the engineers who prepared the plans and supervised the projects. In the selection and design of these projects the department was glad to take into consideration the advice of the consulting engineer, Mr. Girand.

CARLOS HOERNING, Presidente del Instituto de Ingenieros de Chile.

Santiago de Chile, Jan. 30, 1932.

EDITOR'S NOTE—A statement contained in the article describing the Cogoti dam (*ENR*, Nov. 5, 1931, p. 725, appeared to make Mr. Girand responsible for the design of all the dams of the irrigation program. This statement was erroneous and was not written by Mr. Girand, who in fact has not claimed to have designed any part of these dams other than the specific plan shown in the article. Mr. Girand did not see the article before publication and therefore had no opportunity to correct the error.

Name	Type	Maximum Height, Meters	Capacity Cubic Meters Relative	Capacity Cubic Meters Regulating	Designed by		Date
Caritaya	Rockfill	38	27,000,000	76,000,000	N. Salvo of Departamento de Riego	D. de R.	Dec., 1929
Pintananc	Rockfill	60	28,000,000	.....	B. Fuenzalida		
Pachica	Rockfill	63	33,500,000	.....	by order D. de R.		May, 1929
Lautaro	Earth	30	40,265,000	137,650,000	G. Jara		Sept., 1926
J. del Cármen	Rockfill	75	110,000,000	240,000,000	J. Girand,		Dec., 1929
La Laguna	Earth	41	42,000,000	70,000,000	G. Jara		Dec., 1926
Recoleta	Earth	45	100,000,000	132,000,000	C. Rojas		Oct., 1928
Cogotí	Rockfill	75.5	102,500,000	.....	J. Fernandez		Nov., 1929
Huintil	Earth	43	15,000,000	50,000,000	S. Vidal		Dec., 1928
P. Negro	Concrete changed to rockfill, Dec., 1930	45	50,000,000	160,000,000	J. Girand		Jan., 1930
Culimo	Earth	38	10,000,000	12,500,000	O. Santelices		Aug., 1929
Vilcuya	Rockfill	85	80,000,000	250,000,000	M. Ossa		1930
Heuchún	Earth	15	30,000,000	.....	U. Mena		1927
Pitama	Earth	15	1,760,000	.....	O. Correa		1929
Orozco	Earth	15.5	5,100,000	.....	O. Correa		Mar., 1929
Ovalle	Earth	11.5	11,600,000	.....	O. Correa		May, 1928
Perales	Earth	14	10,000,000	.....	B. Michaelsen		Sept., 1929
Purísima	Earth	19.5	2,775,000	.....	S. Vidal		Nov., 1928
Lolol	Earth	26	7,000,000	.....	A. Calvo		June, 1929
Bullileo	Earth	67	60,000,000	98,000,000	D. Retamel		Mar., 1928
Huelehueico	Earth	14.5	4,300,000	.....	R. Rios		Mar., 1928
Laguna del Maule	Combined	15	700,000,000	1,000,000,000	A. Calvo, D. de R.		Sept., 1929

NEWS OF THE WEEK

Federal Financing Of Municipal Work Urged on Congress

AFTER a careful painstaking analysis of the municipal public-works situation over a period of several months, the Michigan Engineering Society has concluded that a national loan for the single purpose of financing municipalities in sound public-works projects offers the best means of prompt restoration of employment with its resultant stimulation of private industry. With this in mind the society is urging its representatives in Congress unitedly to consider this situation as a national emergency and to take such legislative action as will most promptly restore the ability of municipalities to resume their interrupted programs of public works. Thirty technical organizations in Michigan have been called on to take similar action.

The resolution originated in the Michigan Committee on Engineers and Employment, of which John P. Hallihan, chief engineer, Detroit Rapid Transit Commission, is chairman. It is stated that with the exception of road work, public-works programs the country over have been reduced to a stage of practical abandonment for the past two years; that this cessation of construction has intensified and prolonged the industrial depression and paralyzed the private building industry; that the remedies so far proposed and put into effect have dealt only with bank and railroad credit, specifically excepting any provision for loans to cities, and have been practically ineffectual in creating employment, and that by reason of widespread unemployment the revenue of cities has been so reduced as to require not alone the abandonment of capital expenditures on needed public works but also the elimination of current maintenance, in many cases reducing essential public services of health, fire and police protection.

57 Engineers Named for Virginia Road System

Fifty-seven resident engineers to carry out the terms of the road law recently enacted in Virginia, whereby the state takes over the maintenance and construction of practically all county roads (*ENR*, March 17, p. 412), have been appointed by the state highway department. All of the 57 will be designated state-county resident engineers. Included in the list are all of the present 26 state resident engineers. Nineteen of the other appointees represent promotions in the state highway department, virtually all of them having had more than five years' experience. The remaining twelve men now hold the position of county engineer.

Two of the 57 appointments are tentative, owing to the fact that Arlington and Fairfax counties are discussing the question whether they will exempt themselves from the terms of the law.

Cement Price System Criticised by Trade Commission

Sharp criticism of the multiple-basing-point system of quoting cement prices is contained in a report of the Federal Trade Commission on the system, according to a summary of the report just made public. The full report is to be issued later. The system is described as similar to the famous Pittsburgh-plus system formerly used for steel, but with many base points instead of one. Prices in a certain territory are quoted f.o.b. the most favorably situated mill in that territory, and prices at other points are computed by adding freight rates to these points from the mill in question.

Under this system, the commission says, points near the basing-point mill pay too high a price, and distant points often an unprofitably low price. Prices of different mills to the same delivery point become uniform, and "imperfect competition" results. The uniformity of price encourages cross-hauling and causes unnecessary transportation expense; the freight absorption of the industry in 1927 is estimated at 42 million dollars, about 20 per cent of the total selling price. The commission attributes this excessive cross-hauling to "a rather rigid maintenance of mill prices at a relatively high level" due to the basing-point system.

A report on alleged violation of the anti-trust laws by the cement industry as directed by the Norris resolution (Senate resolution 448, 71st Congress, 3d Session) is to be made at an early date, the commission adds.

Hoover Dam Work Faces Delay From Appropriation Cut

WORK on the Hoover Dam project faces the possibility of serious delay and of large losses to the government if the proposed cut in the appropriation should go through. To carry the work forward at the present rate until Feb. 1, 1933, will require $8,000,000. The budget approved $10,000,000 to carry forward the work on the project. This was cut to $8,000,000 in the House but restored to $10,000,000 by the Senate committee. When the Senate recommitted the bill with instructions to reduce the total by 10 per cent, the committee cut the amount to $6,000,000. To reduce that amount would make it necessary to employ 900 fewer men next winter and might jeopardize the diversion of the river.

If the diversion of the river is not effected it would be necessary to close down the work for six months. The cut also would prevent the orderly delivery of materials. Extension of the contract would entail additional expense and the government also would lose by delaying the date when revenue would begin to come in from power sale.

Since the United States has entered into a contract for this project, the contractor could continue the work were he to finance

(Continued on page 563)

Earthfill Dam Saved From Destruction by Cutting Through Side Embankment

Undercutting of spillway paving during flood threatens dam and highway bridge—Engineer loses life in collapse of spillway paving

UNDERCUTTING of the spillway paving of Hunter's Creek dam, a rolled-fill earth embankment 40 ft. high and 500 ft. long at Northville, N. Y., beginning on March 29 when the creek was in flood, progressed so rapidly as to endanger the dam itself and the highway bridge over the spillway and ultimately resulted in the cutting of an artificial channel through an embankment at the south end of the dam to check the flow through the spillway channel. The cut saved the spillway and bridge but resulted in scouring out a channel 150 ft. wide and 45 ft. deep.

Hunter's Creek dam was recently constructed by the Hudson River Regulating District to stabilize the water level in an arm of the Sacandaga reservoir at Northville.

Water level in the Sacandaga reservoir is expected to fluctuate widely. As alternating flooding and draining of the creek valley at Northville would have proved objectionable to the inhabitants of the town, the Hunter's Creek dam was built and a road, flooded by the reservoir, was diverted over the top, crossing the spillway on a two-span concrete girder bridge. The spillway of the dam is at El. 773.0, 2 ft. above the level of the dam at Conklingville which forms the Sacandaga reservoir. The top of the dam is at El. 781.1. The Hunter's Creek dam was built according to standard practices except that both faces have a slope of 1 on 2½ up to El. 765 and 1 on 2 above that point, as both sides will be submerged when the Sacandaga reservoir is full. The whole Sacandaga reservoir side is paved with riprap 2 ft. thick up to El. 776, and the upstream side is similarly paved from the top down to El. 765. The dam has a core wall of concrete 3 ft. thick at the base and 1 ft. at the top set on triple-lap wooden sheet piles driven to 10 ft. below the base. The crest width is 28 ft.

The watershed is 7 square miles and the spillway is 50 ft. wide. The spillway channel downstream was cut from 10 to 15 ft. deep into the natural ground surface, which was of earth, and the channel and the side slopes were covered with a 12-in.

pavement of concrete with hard-heads set in the surface during the process of placing.

Spillway paving undercut

On Tuesday, March 29, it was noticed that at the point where the spillway discharges into Sacandaga reservoir a settlement of the pavement had taken place to a foot or so in depth. There apparently then began an undercutting of the earth supporting the pavement, and successive slabs of the concrete pavement broke and fell into the hole. By Thursday afternoon an area of some 1,500 sq.ft. at the foot of the slope of the spillway channel had caved in to a depth varying from 2 to 7 ft. The superintendent of the reservoir, not being an engineer, did not realize the seriousness of the situation and did not have word sent to Edward H. Sargent, the chief engineer of the Hudson River Regulating District, who was in the South. Mr. Sargent returned to his office on Saturday, April 2, and being advised of the caving went at once to the dam.

Under his direction flashboards were set to check the flow temporarily while stone filling was placed in the channel. The flow was estimated at 80 sec.-ft. Two wooden flumes also were built in an endeavor to divert the flow past the point of caving. Caving, however, continued.

Engineer killed

In an attempt to determine how deeply the caving had cut back under the spillway paving, Henry A. Fleig, assistant engineer, was caught under falling concrete and was killed.

When the dam was built, water in the creek was diverted past the work through a 3-ft. diameter conduit built into the lowest part of the dam. Upon completion of the dam this conduit was closed at its upper end by stop logs. No gate valve was installed, as the people of Northville feared that it might be used to drain the Hunter's Creek pool when the Sacandaga reservoir got unusually low.

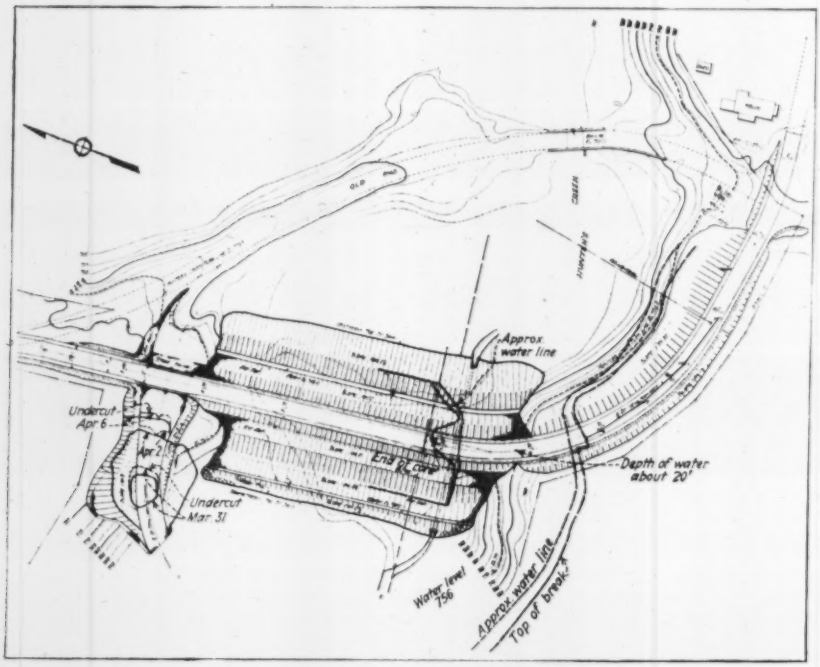
Wooden flumes were constructed below the spillway in a vain attempt to check the undermining of the spillway channel.

Attempts were made to open this conduit, but when they failed it was decided to make a cut through the bank at the south end of the dam to divert flow from the spillway during repairs. The surface material at that point was coarse gravel. Mr. Sargent states that it was appreciated at the time that a deep cut might result from making such an opening, but it was deemed the lesser of two evils. After the cut was opened it developed that fine material lay below the heavy gravel. This material cut through so fast that the pond, estimated to hold 32,000,000 cu.ft. was emptied in an hour. The cut is 150 ft. wide and 45 ft. deep. No damage beyond the cut was done as the flow was absorbed in the larger reservoir below.

The plans for the Hunter's Creek dam were prepared under the direction of Edward H. Sargent and approved by Albert S. Crane, consulting engineer to the district. They were also approved by the department of public works of the State of New York in June, 1929, and the dam was completed in May, 1930.

Mr. Sargent states that the dam will be completely restored as soon as practicable. Just when that can be accomplished has not yet been determined and it possibly may be considerably delayed in view of the fact that the Sacandaga reservoir is now rather rapidly being filled with the spring runoff. Temporary or permanent measures will be immediately adopted for the care of traffic on the highway.

Henry A. Fleig, assistant engineer, who was killed on April 6 by being crushed under a concrete slab which collapsed during the erosion of the spillway, had been employed by the Hudson River Regulating District since May, 1923, on the surveys for and construction of the Sacandaga reservoir. He had received his engineering training from a correspondence school and had been one of the most dilligent and apt young engineers on the staff. Mr. Fleig was 33 years old and is survived by his wife and two small children.



When undercutting in the spillway channel of Hunter's Creek dam endangered the spillway and the highway bridge a cut was made at the south end of the dam, which widened to 150 ft. before the pond drained.

Mass Concrete Discussed at Committee Meeting

Mass concrete problems of the field and laboratory were the theme of the second meeting of committee 108 on properties of mass concrete, American Concrete Institute, held April 7-8 at the University of California, Berkeley. The opening session was attended by more than 50.

The major part of the technical program centered around the cement and concrete problems now being investigated in connection with studies for Hoover Dam. In addition, papers were read and discussed dealing in a more general way with the heat and strength of cement with varying chemical composition, and reports were made covering the field investigation carried out during the construction of various dams recently completed.

New York Engineer Relief Body to Curtail Operations

PROGRESSIVE curtailment of relief work among unemployed engineers in the New York metropolitan area has been begun by the Professional Engineers Committee on Unemployment in order to bring the committee's expenditures down to a point where it will be possible to carry on a consistent relief program throughout the summer months. In adopting this policy the committee follows the lead set by state and city relief committees.

Continuation of the committee's work at its present rate would shortly exhaust its funds and would disorganize services which it is essential to continue in view of the fact that employment conditions in the engineering field are not improving. Also, if the committee's funds are all expended between now and early summer, the committee will have to drop men with families, many of whom may not have found work by that time.

Registration discontinued

Registration of men out of employment was discontinued on April 9 and the branch offices in New Jersey and Westchester and Nassau counties were closed on that date. Notices have been sent to unmarried non-members on the P.E.C.U. payroll advising them that they cannot be carried after April 15 and to married non-members and unmarried members that they cannot be carried by the committee after May 1. Married men and single men with dependents in Class A—that is, those in most need of aid—will be carried on by the committee after May 15 if they are members of the Four Founder Societies or were members in good standing at the time they lost their jobs.

Up until the middle of February all engineers, whether members of the societies back of the P.E.C.U. or not, were carried by the committee. About half the men placed by it up to that time were non-members. Heavier demands on the committee's funds made it necessary to set up limitations as to the men aided and the membership limitation was adopted by the committee as being the most equitable in view of the fact that practically all the contributions to its fund had come from members of the four engineering societies which it represents. This limitation, however, affected only men on the committee's own payroll; men placed with other relief agencies were placed without regard to their society membership.

To reduce payroll

After May 15 the committee's payroll will be reduced from its present total of about $4,000 a week to $1,500. This will permit the continuation of part of the research work now in progress, will care for the neediest cases now carried by the committee, and will give the committee a reserve to take care of other married men now in jobs financed by city or state relief agencies as they are released by the closing down of those agencies.

During the spring and summer months special attention is to be given to the work of the P.E.C.U.'s committee which is seeking permanent jobs for men in fields outside of engineering. This committee has directed its attention to diverting as many men as possible away from engineering into other forms of work in order to diminish the number of men who will be found out of work again in the fall due to the seasonal closing down of engineering work.

No fund appeal this summer

No drives for funds are to be made during the summer, but new contributions or the continuation of regular monthly contributions will be welcomed by the committee because the demands upon it are expected to be in excess of its budgeted weekly expenditure. If, as the committee now expects, unemployment of a serious character develops in the fall, a new appeal for funds will be made. By keeping the nucleus of its organization together, it will be able to sense this need earlier than was possible when the work was first undertaken last fall, thus putting itself in the position of being able to get out its appeal for funds in advance of other general relief agencies, also better to judge what will be its requirements for the winter.

Hoover Dam Work Faces Delay

(Continued from page 561)

himself. There would be no doubt of his ability to collect.

Hoover Dam notes

The 41x56-ft. enlarged heading in tunnel No. 1 at Hoover Dam was holed through on April 2, thus completing the headings of this size in all four of the diversion tunnels. Pioneer headings in the inclined tunnels were stopped 465 ft. from the roof of the Nevada tunnel and 469 ft. from the roof of the Arizona tunnel. The pioneer headings from the diversion tunnels to the intake towers progressed 60 ft. from the roof of tunnel No. 2 and 43 ft. from the roof of tunnel No. 3 during the week ended April 2. A total of 2,569 ft. of concrete runners for crane tracks has been poured in tunnels No. 2, 3 and 4. Six 40-ft. sections of invert have been poured in tunnel No. 2 and five sections in tunnel No. 3. During the week under review the mixing plant and the gravel pit were operated on a three-shift basis. Progress to date in the diversion tunnels is shown in the accompanying table.

Tunnel	Length	Sec.	Progress to Apr. 2, 1932 Inlet	Outlet	Total
No. 1	4,301	H	(Holed through Apr. 2)		4,301
		B	.....	324	324
		T	.....	.....	.....
No. 2	3,879	H	(Holed through Feb. 3)		3,879
		B	1,213	1,215	2,428
		T	1,208	1,491	2,699
No. 3	3,560	H	(Holed through Jan. 31)		3,560
		B	1,130	1,470	2,600
		T	1,070	1,520	2,590
No. 4	4,166	H	(Holed through Mar. 3)		4,166
		B	1,500	1,420	2,920
		T	1,723	1,322	3,045
All	15,905	H	.....	.....	15,905
		B	.....	.....	8,272
		T	.....	.....	8,344

H — 41x56-ft. enlarged heading; B — 15-ft. bottom bench; T — trimming.

The number employed on the project at the end of the week was 4,200 persons. Of these 3,400 are on the payroll of the Six Companies and its subcontractors; 250 are working for the government; 350 for contractors on government construction and 200 are engaged on private construction. One workman was killed by a fall of rock in tunnel No. 3 during the week.

Washington Notes

By Paul Wooton
Washington Correspondent

BEFORE acting on legislation authorizing a federal bond issue for the immediate completion of all adopted rivers and harbors projects, the Senate commerce committee has indicated that it will consider certain modifications. In its present form, the bill provides for a bond issue of $500,000,000 to finance the completion of the present program over a period of five years. It is now believed that it would be advisable to exempt from this expedited program projects adopted by Congress but not indorsed by the war department. The committee also is inclined to favor an amendment that would remove from the bill any specification of the exact amount to be raised.

Execution of all approved river and harbor projects as authorized by Congress for commerce and navigation aid is estimated to call for expenditures of $215,000,000. In addition to the above-named sum, about $46,000,000 would be required to complete work whose completion is not now justified in the interests of commerce and navigation.

Authorized appropriations for several major projects, including the upper Mississippi, Missouri and Tennessee rivers, do not provide for their completion. Such completion would require $216,000,000 more, making a total of $431,000,000 as the cost of completing all approved projects whose completion is now justified in the interest of commerce and navigation.

In testimony before the committee, Major Gen. Lytle Brown, Chief of Engineers, stated that $100,000,000 could be used during the next fiscal year.

Bids Asked for Hoover Dam Bulkhead and Stoney Gates

Bids will be received up to 2 p.m. May 2 by the U. S. Bureau of Reclamation, Custom House, Denver, Colo., for the furnishing of 7,000,000 lb. of bulkhead and stoney gates and gate frames and guides for Hoover Dam.

The items to be furnished, under specifications No. 533 include: two 50x50-ft. bulkhead gates with gate frames, roller guides, etc.; two twin-cylinder hydraulic gate hoists; two 50x35-ft. stoney gates with gate frames, guides, etc.; and two electric motor drive gate hoists. Bids are asked f.o.b. cars factory shipping point.

Estimates Needed Construction at Twenty Billions

Sound self-supporting construction projects ready to get under way now or in the next few years are estimated at some 20 billion dollars by Francis Lee Stuart, past-president of the American Society of Civil Engineers, in a statement issued on his behalf by American Engineering Council. His estimate includes public works and modernization of buildings and plant. "The best way is to press for those expenditures that improve the average of our population in health, decency and self-supporting work," he states. Sale of bonds he considered most helpful in time of depression.

Lack of Funds Holds Up Columbus Sewage Plant

The plans for a sewage-disposal plant for Columbus, Ohio, ordered by the Ohio board of health to replace the present plant, are being held up indefinitely by lack of funds. Because of a law passed at the last session of the general assembly limiting bond issues for this sort of work, no bond issue can be made to cover the cost, which is estimated at $3,500,000. Bond issues can be voted on only at the general elections in November under Ohio law. The alternative of devising a system to charge property owners a fee for service is being considered, but it is likely that nothing will be done toward awarding the contract in 1932.

Seattle Contracts May Favor Local Steel Companies

Advised by the prosecuting attorney that it cannot give preference to Seattle fabricated steel, the board of commissioners of King County (Seattle), Wash., is considering a plan proposed by four steel companies in the city to insert a clause in all contracts for fabricated steel requiring that all steel shipped to the city by water, for use in county projects, be sand-blasted and repainted. By thus placing outside steel at a disadvantage, local companies would be favored, and, it is said, the plan would not be subject to legal objections.

Irrigation and Reclamation Bondholders Organize

Formation of the California Irrigation and Reclamation District Bondholders Association has been announced, with headquarters at San Francisco. Its purpose is to protect bondholders in case of default of districts, to resist efforts to weaken the irrigation and reclamation laws, to aid refinancing plans and to attempt to cure the epidemic of defaults. More than one-third of California's irrigation districts, representing 53 per cent of their total outstanding bonded debt, are wholly or partly in default, either in principal or in interest.

The cost of maintaining the association will be covered by the contributions of bondholders joining the association based upon and in proportion to the total number of irrigation and reclamation bonds owned. The cost per bond will depend upon the number of bonds represented in the association, but will be limited to $2 per bond in any one year. The association is a non-profit corporation.

Concrete Pavement Yardage

Below is a tabulation of concrete pavement yardage awarded in the United States during the month of March, divided according to roads, streets and alleys, and the totals for the three months' period ended April 2:

	During March	To April 2
Roads	5,457,222	10,793,146
Streets	539,005	943,996
Alleys	9,015	47,154
Totals	6,005,242	11,784,296

Revised Train Schedule for Memphis A.W.W.A. Convention

A revised schedule for the special train from the East to the American Water Works Association convention in Memphis, Tenn., May 2-6, has been announced by John S. Warde, chairman of the transportation committee. The special will leave Pennsylvania Station, New York, at 3:40 p.m. on April 30 and will arrive at Memphis at 9 p.m. on May 1. Details of the train schedule follow:

			(E.S.T.)
April	30	Lv. Boston	7:30 a.m.
"	"	" New York, Penn. Sta.	3:40 p.m.
"	"	" Newark	4:00 p.m.
"	"	" Trenton	4:54 p.m.
"	"	" North Phila.	5:18 p.m.
"	"	" Washington	4:00 p.m.
"	"	" Baltimore	4:50 p.m.
"	"	" Harrisburg	7:30 p.m.
May	1	Ar. Pittsburgh	12:30 a.m.
"	"	Lv. Pittsburgh	1:00 a.m.
"	"	" Columbus	5:25 a.m.
"	"	Ar. Cincinnati	8:30 a.m.
"	"	Lv. Cincinnati	9:00 a.m.
"	"	" Louisville	12:00 p.m.
"	"	Ar. Memphis	9:00 p.m.

COSTS AND CONTRACTS

ENR Index Numbers

Cost			Volume	
April, 1932	**153.12**	**March, 1932**	**97**
March, 1932	157.24	Feb., 1932	105
April, 1931	191.63	March, 1931	278
Average, 1931	181.35	Average, 1931	220
Average, 1930	202.85	Average, 1930	260
1913	100.00	1913	100

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of April 14, with some comparisons, total as follows:

(In Thousands of Dollars)

Engineering Construction	Week of April 14, 1932	Average Week April to Date	Average Week April, 1931
Federal government	$3,184	$3,396	$5,277
State and municipal	14,137	11,292	29,937
Total public	$17,321	$14,688	$35,215
Total private	9,433	6,992	28,166
Grand total	$26,754	$21,680	$63,381

Cumulative, all classes, Jan. 1 to April 14:

1932	$296,995
1931	807,610

Brief News

MANAGER FORM of government has been adopted by Fairfax County, Virginia, County Engineer Larkin becoming the first county manager.

NO NEW ROAD CONTRACTS will be let by the Quebec department of highways this summer, because of reduced revenue. Road maintenance will be continued, however.

ZONING ORDINANCES have been adopted in Bennington, Brattleboro, Newport and Springfield, Vt. Similar ordinances were proposed but defeated in three other Vermont towns.

TO PROVIDE for construction of a power house at Diablo Dam and a new transmission line, the city light department of Seattle is preparing to call for bids on a $3,000,000 issue of 6 per cent lighting bonds.

NO TOWN TAXES, with the exeception of the school tax, will be levied for 1932 in Orleans, Vt., which has $12,000 in the treasury, sufficient to provide the usual appropriations. This favorable tax situation, the town trustees say, is due to returns from municipally owned water and electrical plants and the municipal building. All three made profits last year.

THE COMPLETED Summer Ave. viaduct in Memphis, Tenn., one of the entrances of the Memphis-to-Bristol highway, was opened to traffic on March 14. This viaduct, which cost $300,000, was built by the S. & W. Construction Co., of Memphis, from designs of Walter Schultz, of Memphis. The city, railways and state cooperated in the building.

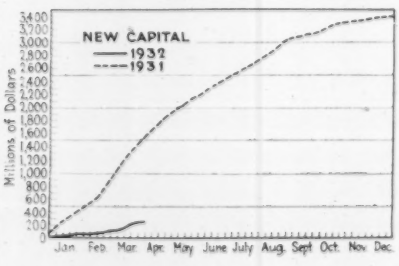
ROADBUILDING is effective in providing employment, it is announced by Harvey A. Wooster, director of the Massachusetts Commission on Stabilization of Employment, who has compiled figures on the subject. Mr. Wooster states that for every million dollars spent by the State of Massachusetts on highway construction, 6,000 workers receive employment for one month.

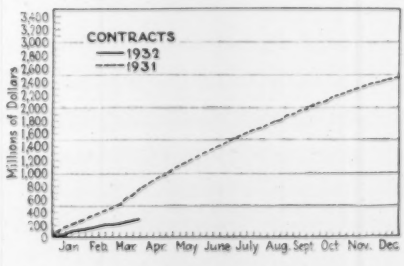
STREAM POLLUTION by sewage and industrial wastes has led the government of Thuringia to establish an advisory bureau of waste disposal. This bureau is additional to the existing hydrological department of the state government, the Thuringsche Landesanstalt fur Gewässerkunde.

Capital and Contracts

New capital issued in the week ended April 9 totaled $10,000,000 — $5,000,000 public and $5,000,000 private. The total for the week ended April 2 was $18,000,000, all of which went for public improvement bonds. The average week in March was $30,000,000, while that for April, 1931, was $111,000,000.

Cumulatively, the total for the period Jan. 1 to April 9, inclusive, is $241,000,000, compared with $1,428,000,000 in the corresponding period last year.





Personal Notes

APOLONIO PINO has been appointed assistant district highway engineer at Santa Fe, N. M., to succeed GUY MAYES, who has been transferred to the state highway department offices.

E. G. CAHILL, of Cahill Brothers, San Francisco contractors, has been appointed manager of the San Francisco public utilities by the Public Utilities Commission. The municipal railway, the water department, the Hetch Hetchy system and the municipal airport will be under the management of Mr. Cahill.

HOWARD B. HALL has been appointed director of the industrial division of the firm of Murray & Flood, consulting engineers and managers.

RAYMOND F. FOWLER, major, Corps of Engineers, has been detached from duty as district engineer at New Orleans and assigned to the office of the Chief of Engineers at Washington.

GEORGE R. LE BARON has been appointed by the Metropolitan Water District of Southern California to handle matters concerning the acquisition of the right-of-way for the proposed Colorado River aqueduct.

Prof. GEORGE F. BATEMAN has been placed in charge of the schools of engineering of Cooper Union, New York City, with the title of acting dean, succeeding Dean Francis M. Hartmann, who died recently after 30 years' service on the engineering faculty.

LUDSON D. WORSHAM, major, Corps of Engineers, has been relieved from duty in the office of the district engineer, Memphis, Tenn., and ordered to report about Aug. 25 to the superintendent of the U. S. Military Academy at West Point for assignment to duty.

HENRY A. YANCEY, city manager of Charlottesville, Va., since 1925, has been selected as city manager of Petersburg, Va. He was formerly a civil engineer with the West Virginia and Virginia highway commissions.

WILLIAM D. A. ANDERSON, lieutenant-colonel, Corps of Engineers, who has been district engineer at Mobile, Ala., has been assigned to duty, effective July 1, at headquarters of the Third Corps Area, Baltimore, Md.

J. Q. A. GREENE, former secretary and treasurer of the Gunite Concrete & Construction Co., located at Kansas City, Mo., is now vice-president of the company and has been placed in charge of the Chicago territory.

A. S. DAWSON, chief engineer, department of natural resources, Canadian Pacific Railway Co., has been retired on account of ill health after 37 years of service. He has been succeeded by A. GRIFFIN, who also continues as superintendent of operation and maintenance, Eastern Section.

RALPH CRISWELL, for many years Colorado River agent of the Los Angeles board of water and power commissioners, has been reemployed by the board. The position was abolished about a year ago. Mr. Criswell's work will be largely in Washington, D. C., in connection with land and rights-of-way matters.

Obituary

HARTZELL MCCOY, assistant division engineer in charge of maintenance in the Ohio state highway department, died on April 7 in Columbus from pneumonia, which set in after he had undergone a mastoid operation.

W. B. MACKENZIE for 42 years a member of the civil engineering staff of the Canadian National Railways, died recently at his home at Daytona, Fla., aged 85. He became assistant chief engineer in 1879 and in 1897 was advnced to chief engineer. Mr. MacKenzie retired in 1914.

HALFORD ERICKSON, vice-president of the Byllesby Engineering & Management Corp., Chicago, died on April 7 at the age of 67. Mr. Erickson was commissioner of labor for Wisconsin from 1895 to 1905, when he was appointed a member of the state railroad commission. In 1916 he resigned this position and in 1918 became associated with the Byllesby corporation. While with the Wisconsin railroad commission he drafted laws for the regulation of public utilities, which laws have been the basis of similar measures in other states.

ABRAHAM M. REYNOLDS, chief engineer and general superintendent of the Essex County (N. J.) Park Commission until his retirement because of ill health last September, died in Newark on April 7. Mr. Reynolds entered the service of the park commission as an assistant engineer in 1895 and was made chief engineer in 1900. He was 62 years old.

MICHAEL F. FIELDING, contractor and engineer, of St. Paul, Minn., died suddenly in that city on April 2, at the age of 82. After twenty years in the employ of Philadelphia civil engineers specializing in railroad, bridge and highway construction, Mr. Fielding formed the partnership of Fielding & Shepley, St. Paul, in 1887. The firm specialized in bridge and highway work as engineers and contractors, building many roads and railroad and highway bridges in the United States and Mexico. Since 1920 because of ill health Mr. Fielding had not been active.

LAVERNE WARD SPRING, chief chemist and metallurgist of the Crane Co., Chicago, died on March 23 in his 56th year. After his graduation from the University of Michigan in 1901, Mr. Spring first went with the Illinois Steel Co. and later was connected with the Wolverine Portland Cement Co. He had been with the Crane Co. since 1903. Mr. Spring was a member of the American Society for Testing Materials and was the author of "Non-Technical Chats on Iron and Steel," as well as various articles on chemical and physical testing and metallurgy.

BENJAMIN KENDALL EMERSON, professor emeritus of geology at Amherst College, died on April 7 at the age of 88 years. Prof. Emerson served Amherst College for 47 years and retired from active teaching in 1917. From 1890 to 1906 he was an assistant geologist for the U. S. Geological Survey and in 1906 became geologist, holding the position until 1920, when he retired. He was president of the Geological Society of America in 1899-1900 and vice-president of the American Association for the Advancement of Science in 1896.

EDWIN S. GORDON, senior member of the architectural firm of Gordon & Kaelber, Rochester, N. Y., died at his home in that city on April 5, at the age of 65. Mr. Gordon designed the buildings on the New River campus of the University of Rochester. More recently he had been devoting his time to plans for the proposed Rochester Civic Center, the new Rundel Memorial Library and other buildings contemplated by the Women's College for the University of Rochester.

GEORGE J. KUHRTS, president and general manager of the Los Angeles Railway Co., died suddenly on April 1 in Los Angeles, from a blood clot on the brain, while sitting at his desk in conference with other officials of the company. He was 63 years old. He joined the Los Angeles city engineering department in 1886 and three years later went to the Southern Pacific Co. in the maintenance-of-way department in Arizona. In 1892 he was made assistant city engineer of Los Angeles and held that post until 1895. He became chief engineer of the Los Angeles Railway Co. in 1902 and president and general manager of the company in 1927.

SOCIETY CALENDAR

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Atlantic City, June 20-24.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Yellowstone National Park, July 6-9.

AMERICAN WATER WORKS ASSOCIATION, annual convention, Memphis, Tenn., May 2-6.

AMERICAN WELDING SOCIETY, annual meeting, New York City, April 27-29.

NEW ENGLAND SEWAGE WORKS ASSOCIATION, annual meeting, Boston, April 25.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, 40th annual meeting, Oregon State College, Corvallis, June 29-July 1.

BUFFALO BRANCH, Associated General Contractors of America, at its meeting on April 2 elected Edward C. Boehm president, Chester W. Wright vice-president, Fred D. Folsom treasurer, and Richard C. O'Keefe secretary.

CENTRAL STATES SECTION, American Water Works Association, announces that its 34th annual convention will be held Sept. 22-23, at Erie, Pa.

CONCRETE REINFORCING STEEL INSTITUTE held a sectional meeting on April 8 in Philadelphia. The morning was devoted to a review of the Institute activities for the last fiscal year and a discussion of matters of interest and formulation of plans for the ensuing months. In the afternoon regional conferences were held for New York, Philadelphia and Washington groups.

MASSACHUSETTS SAFETY COUNCIL and cooperating organizations will hold the eleventh annual Massachusetts state conference on industrial and public safety in Boston April 20-21. There will be an exhibit of safety devices, and papers will be read on industrial safety, fire prevention and highway safety.

SAN FRANCISCO BUILDERS' EXCHANGE has reelected W. H. George president for 1932-33. Other officers elected were: vice-presidents, Joseph B. Keenan, Emil Hogberg and Charles W. Carle; secretary, R. H. J. Forbes; treasurer, Alexander Mennie.

STRUCTURAL ENGINEERS SOCIETY OF NEW YORK, at its fourth annual meeting, elected officers for the ensuing year as follows: president, Warren W. Chapin; vice-presidents, H. V. Spurr and Charles L. Lange; secretary, Howard H. Snyder; treasurer, Charles C. Hurlbut.

Construction Equipment and Materials

New Equipment in Brief

Bar Bender—A new bending roll, designed for the bending of reinforcing bars up to 1½ in. in size has recently been developed by the Buffalo Forge Co., Buffalo, N. Y. The machine, powered by a 5-hp. electric motor or 7½-hp. gasoline engine, will bend 1½-in. bars at the rate of 70 ft. per minute. The diameter range varies from 20 in. up. The weight of the machine, including the motors, is 1,825 lb.

Fire Hydrant Guard—Aqua Products Co., Bristol, Conn., has announced a compression hydrant guard designed to give positive protection against breakage of hydrants from being struck, sidewiped, backed into or skidded into by vehicular traffic. The guard consists of two channel boxes of 1¼-in. boiler plate, each containing three eleven-coil steel compression springs of ⅜-in. stock, 6 in. long and 3 in. in diameter. These chanel boxes are the compression chambers, the front plate of which is so designed that it absorbs the shock through the compression springs. The guards do not interfere with the use of the hydrant.

Portable Welders—Schramm, Inc., West Chester, Pa., has announced a complete line of portable engine-driven welders in four sizes designed to meet the exacting requirements of welding in the construction industry. These four sizes, 200-, 300-, 400- and 600-amp. units, contain the latest improvements in welders of this type and are capable of welding successfully over a wide range of current. The generator unit is designed for rapid voltage recovery. A transforming reactor automatically steadies and regulates the arc. Any type of mounting for portable use can be supplied, such as spring trailer, highway trailer, two wheel pneumatic tired, rubber-tired wheels, steel wheels, or skidded or for mounting on all standard makes of motor trucks.

Ignition System—The United American Bosch Corp., Springfield, Mass., has designed a new rapid-transit ignition system especially for use on buses, trucks and other gasoline-powered units in heavy-duty fast service. The new product, known as the Rapid Transit Magneto, includes three types of six-cylinder magnetos. The three types are adaptable to a single ignition system, dual ignition operation or for use on engines with both battery and magneto ignition having two spark plugs per cylinder operating simultaneously. Features of the new magneto are high-tension distribution, a stationary interrupter operated at half engine speed and a stationary winding of large size delivering a spark of intensity not heretofore possible in any except racing cars.

Steel Expansion Joints for Concrete Pavements

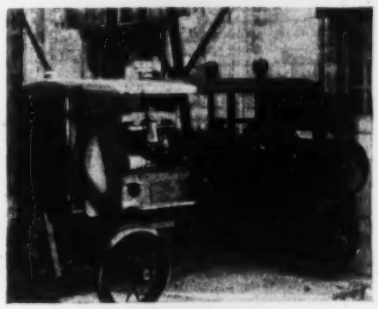
An entirely new type of steel expansion joint for concrete pavements has been developed by the "PaveCure" Corp., 2549 State St., San Diego, Calif., and is designated as the Air-Flex expansion joint. The company is also manufacturing a line of "PaveCure" steel transverse contraction joints and longitudinal construction joints. The Air-Flex expansion joint is premolded and held in place during pouring of the concrete by stakes and an inner form. Briefly, it consists of two parallel steel plates, flanged at the bottom and about 2 in. from the top of the slab. These plates are set as shown in Fig. 1. After the concrete has been poured but before it has reached final set the stakes are pulled and the inner form raised slightly to assure removal later. The next day the inner form is pulled and a mastic is poured along the bottom of the groove between the two plates to a depth of 1 in. Then the tops of the plates are pulled together with a special tool and a V-shaped steel cap is placed over the tops of the plates, with a tongue projecting downward, as shown in Fig. 2. A mastic seal is then poured to fill the slot remaining above the cap, as is also shown in Fig. 2. This type joint provides a permanent air space between the adjoining slabs and prevents any water from getting through to subgrade. It is designed to allow 60 per cent compressibility below normal constructed width and 80 per cent expansibility above this width. Sliding metal plates close the ends of the joints.

The "PaveCure" contraction and construction joints are shown in Figs. 3, 4 and 5. They are built plain, tongue-and-grooved or corrugated. These joints consist of metal sheets flanged near the top. They are installed with a temporary form at the top which provides a groove to be filled with mastic. When used for contraction joints, the sheets are held in place temporarily by stakes. When used for construction joints, a form supports one side, while the other is held by stakes. The flange on the form side is bent from a vertical to a horizontal position before the adjacent slab is placed.

Air-Flex steel expansion joint and three types of steel contraction and construction joints.

Four-Cylinder V-Type Portable Air Compressor

Curtis Pneumatic Machinery, Co., St. Louis, has rounded out its line of portable air compressors with a new 240-cu.ft. V-type four-cylinder machine. A feature of these units is the carbon-free head and valve design of the compressor. The whole valve unit assembly for a cylinder can be conveniently removed by taking off four nuts without disturbing the discharge piping or water connections. This can be done even with a hot compressor. The coupling between the engine and compressor can be disconnected with ease to permit warming up of the engine independent of the compressor. An aftercooler is located between the compressor and tank directly in line with the air blast from the fan.



New Curtis 240-ft. compressor.

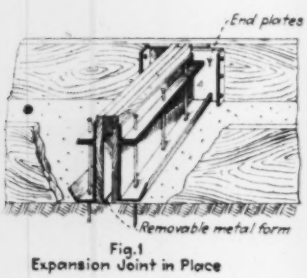


Fig.1
Expansion Joint in Place

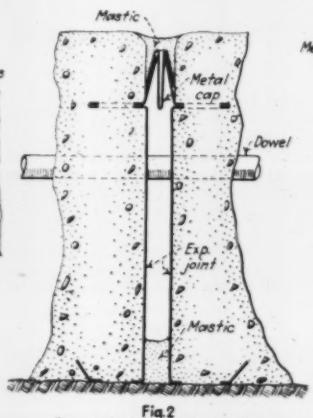


Fig.2
Completed Expansion Joint

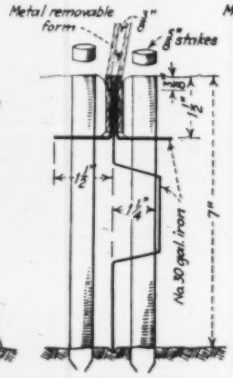


Fig.3
Tongue-and-Groove Contraction Joint

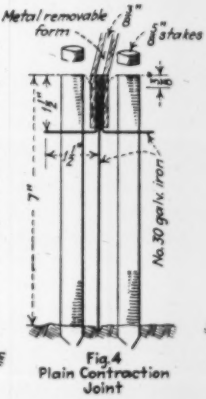


Fig.4
Plain Contraction Joint

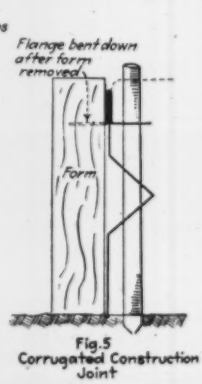


Fig.5
Corrugated Construction Joint